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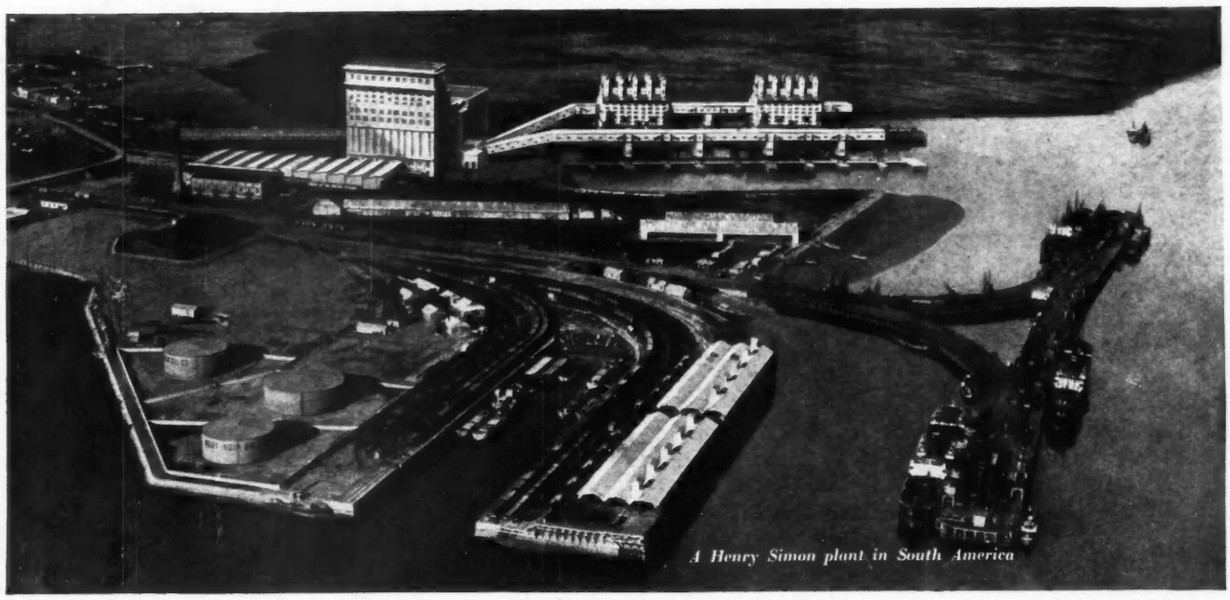

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FLEXIBLE CONCRETE MATTRESSES FOR RIVER-BANK PROTECTION.

THE lower reaches of the Mississippi River, which has a total length of 3,160 miles, have been subjected many times to disastrous floods, and a very extensive system of dikes, or levees, as they are termed, has been built to protect low-lying lands. The Mississippi is joined by the Missouri at St. Louis, and by the Ohio River, into which the Tennessee River flows, at Cairo. The reach between this latter town and New Orleans, at the mouth, is known as the Lower Mississippi and the current velocity in this section ranges from 5 ft. to 12 ft. a second, and even higher in some cases. To a considerable extent, the banks of the river consist of surface silts and clays underlain by sand, and, quite apart from any question of dike construction, the protection of the banks from erosion presents a serious problem. Owing to the removal of sand from the bottom of an underwater slope, the bank may become unstable and collapse; the recession owing to this action may amount to as much as 500 ft. in a year. The necessity for the adoption of remedial measures was recognised many years ago and the Mississippi River Commission was set up in 1879 "to mature a plan or plans as will correct, permanently locate and deepen the channel, and protect the banks of the Mississippi River." After study of the matter, the Commission decided that, of 2,000 miles of bank above Cairo, 700 miles were in need of revetment. The carrying out of this heavy task has been proceeding from that day to this.

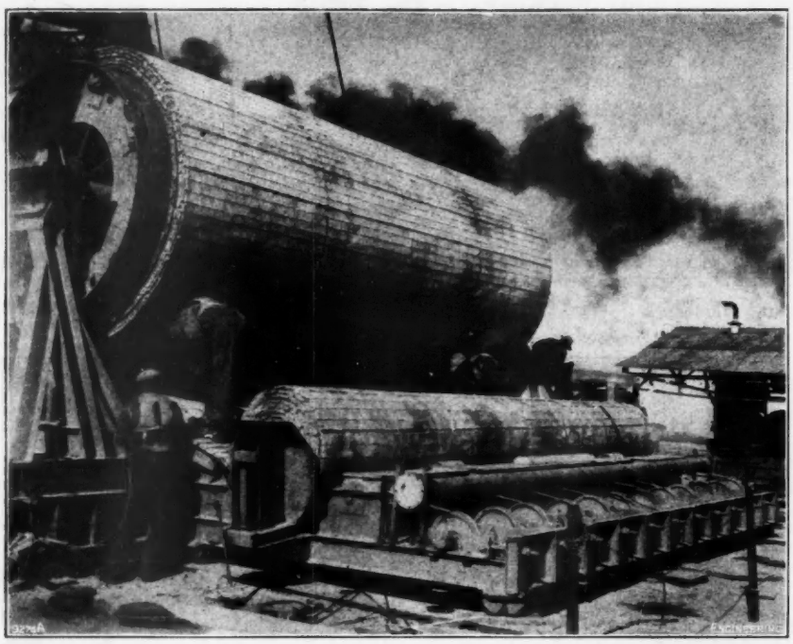


FIG. 1. ROLLED-TYPE FLEXIBLE CONCRETE MATTRESS.

The caving-in of a bank is normally due to the sweeping-away of sand from the lower part of the underwater slope, so that the angle of repose is exceeded, the bank becomes unstable and collapses. Experience has shown that when a bank is stabilised by revetment, so that the supply of fresh sand to the stream is cut off, the river nearly always deepens. At the site of caving banks, the river depth varies from 40 ft. to 120 ft. below low-water elevation and the banks may rise 30 ft. above this level, so that the total height of bank which it is necessary to protect may vary from 70 ft. to 150 ft. As banks, particularly in the underwater portions, may be of irregular contour, it is desirable, or even necessary, that the revetment should be flexible and in early practice they were protected by brushwood mattresses. In a survey of the development of revetment procedure which appeared in the April and May, 1947, issues of *Concrete*, Mr. Raymond H. Hass, of the Corps of Engineers operating for the Mississippi River Commission, states that more than 50 years ago it was realised that concrete might be adopted for river-bank revetment. It was assumed that it would be suitable only for the upper portions, but in 1914, in view of a threatened shortage of willow canes, from which the brushwood mattresses were made, experiments were begun for the purpose of developing underwater mattresses of concrete. Extensive progress has been made since that time and flexible concrete mattresses of great technical interest are now in use.

In the first attempts to develop a satisfactory type of underwater concrete revetment, monolithic reinforced mattresses were constructed on barges provided with sloping ways from which the mattresses were launched by cantilever cranes. After initial experiments with small slabs, mattresses 125 ft. by 50 ft. by 3 in. thick, were successfully built and launched, and before the type was abandoned some slabs 240 ft. by 12 ft. by 3½ in. were laid. In initiating this work, it was assumed that the thin mattresses would crack sufficiently to conform to irregularities in the underwater bank, but would be prevented from disintegrating by the reinforcement and would settle down as a type of mosaic pavement. This assumption appears to have been justified, and the main reasons for the abandonment of the monolithic mattress were the difficulties of launching and the fact that it was found impossible to control the final position of the mattress. The procedure was also very expensive.

As long ago as 1915, the development of articulated concrete mattresses was put in hand and the procedure adopted, with modifications suggested by experience, is still followed, but a further important advance was made in 1943, when the so-called flexible mattress was devised. This latter type, which may be rolled up for transportation, has advantages from the points of view of handling and laying. An articulated mattress which is able to adapt itself to the contour of the bank on which it is laid has obvious advantages over a monolithic mattress which beds itself only by fracture of its structure. The present standard type of articulated mattress consists of 20 blocks, each 3 ft. 10½ in. long, 14 in. wide, and 3 in. thick. The blocks are spaced 1 in. apart on a non-corroding reinforcement. The twenty 14-in. wide blocks, 1 in. apart, make up a mattress 25 ft. long and nearly 4 ft. wide. A number of these mattresses are assembled side by side to make up a bank paving. The arrangement will be understood from Fig. 5, on page 348, which shows a launching, or laying, operation. The reinforcement, on which the blocks are carried, consists of three longitudinal wires passing through the full length of the mattress and provided with loops at the ends, so that connection may be made to other mattresses. The longitudinal wires are connected by transverse reinforcement consisting of rectangles made of 0·18-in. diameter wire. The rectangular wire frames project from each end of the blocks, forming brackets by means of which mattresses may be connected together side by side. Launching cables are also connected to these brackets when a mattress is being laid, so that the launching stresses do not come on the longitudinal reinforcing wires. The reinforcement is made from copper-coated steel.

Up till the year 1940, the articulated mattresses were cast on floating plant, but as the volume of work increased it became necessary to install casting plants of greater capacity; the immobilisation of a large number of barges during the curing period was inconvenient and expensive. Eight construction yards have now been set up on the river between Cairo and New Orleans; they have capacities varying from 40 to 100 thousand 4-ft. by 25-ft. mattresses a year and ample space is available to carry stocks of finished mattresses. Standard Portland cement is used for the concrete, which is required to have a compressive strength of 2,000 lb. per square inch at seven days; in some cases an air-entraining mixture is used. Casting takes place in steel forms, slotted to hold the reinforcing wires. The concrete is run into the forms from side-tip trucks fed from a central mixing plant, compacted with vibrators, and finished with the back of a shovel. When the concrete has taken an initial set, usually in about four hours, the steel forms, which have previously been coated with a mineral oil to allow of easy separation, are removed. The first mattress of a batch is cast with the forms lying at ground level; when it is finished, it is covered with two layers of heavy paper, over which the forms are re-assembled and a second mattress is run, the process then being repeated for a third mattress, and so on until a pile of 12 has been built up. The heap is then left for ten days or so for curing.

For laying, the mattresses are transferred to sinking barges, the piles of 12 being handled as single units. They are lifted in a built-up frame in which they are transported from the stock yard by a travelling gantry hauled by a tractor. The gantry carrying the frame with its pile of mattresses delivers to an electric hoist, which is shown in Fig. 6, on page 348, in which the frame carrying the mattresses can clearly be seen. The hoist is carried on rails and when loaded is traversed to the river side and out on to two short piers, which are visible in Fig. 6. Barges are run in between the piers and the piles of mattresses are stacked on the flat decks. A loaded barge can be seen in the background of Fig. 7, on page 348.

For placing the mattresses in the river, the loaded barges are towed into position at the outboard side of a sinking barge. This latter vessel has a sloping deck and at the commencement of operations is moored close to the river bank with the deck sloping landwards. As the mattresses are laid, the sinking barge moves outward, its movement being controlled by a mooring barge alongside. A general view of a laying operation in progress is given in Fig. 7, the sinking barge being shown in the foreground and the mooring barge on the left. The inboard edge of the deck of the sinking barge is formed as a smooth 8-ft. radius curve over which the mattress slides as it enters the water. The barge shown in Fig. 7 is laying a mattress built up of 25 4-ft. units of a total width of 100 ft., but 35-unit barges, laying 140-ft. mattresses, are also in use.

The sinking barge is equipped with two cranes which are employed to transfer the mattress piles from the mat barges to the deck of the sinking barge. They are capable of handling 90 piles per hour. The cranes are shown in operation in both Figs. 5 and 7. The deck of the sinking barge is divided into a

FLEXIBLE CONCRETE MATTRESSES FOR BANK PROTECTION; RIVER MISSISSIPPI.

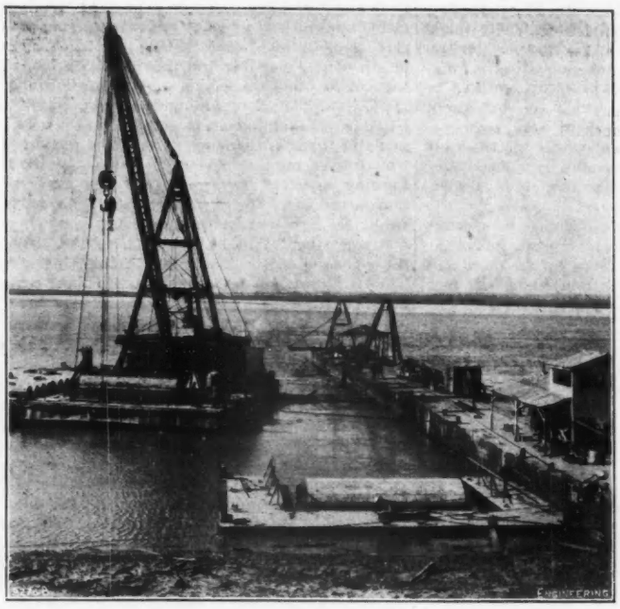


Fig. 2. Sinking Operations; Rolled-Type Flexible Concrete Mattress.

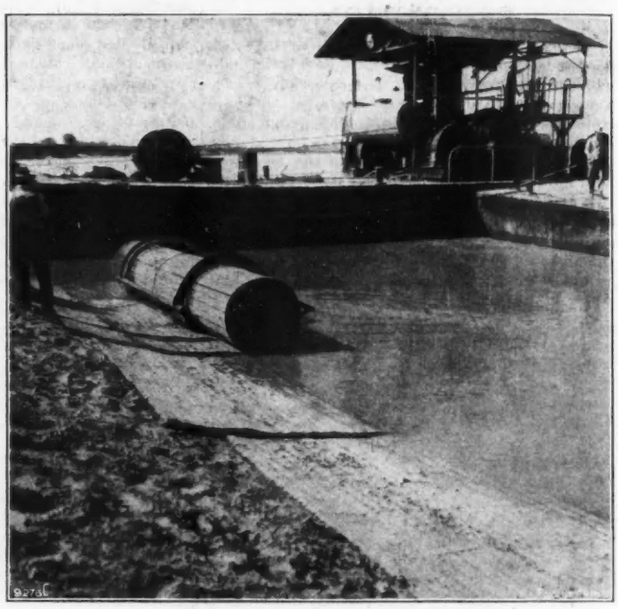


Fig. 3. Flexible Concrete Mattress being Laid by Spreader Bar.

series of ways, each corresponding in width to a unit mattress and each equipped with two roller trains on which the mattresses travel. These rollers can be seen in Fig. 5. Below deck, the barge has a machinery alley, for its full width, which contains winch equipment for paying-out the launching cables to which the mattresses are attached. At the start of operations, the launching cables are secured to anchors on the bank, and as the piles of unit mattresses are lifted on to the deck they are secured to these cables by the assembly gang. For the main part of the laying operation, the mattress is paid out over the rounded edge of the deck as the barge moves outward, as shown in Figs. 5 and 7, but for the shore end of the mattress a different procedure is necessary, as the inner end extends above the water line. To lay this shore connection, a series of cantilever arms is run out from the barge to the bank, as shown in Fig. 8, on page 348, and the mattress is laid on them. The arms are then drawn back into the barge and the mattress settles down on the bank. This operation is not performed until the first 25-ft. length of mattress has been assembled. The total length of mattress laid may extend to as much as 400 ft. into the river, and as the barge moves outward the 25-ft. sections gradually added are connected by twisting wires through loops in the longitudinal reinforcement. The launching cables are continuous. When a complete mattress has been laid, the barges are moved upstream and a second mattress is sunk with an overlay of 5 ft. over the preceding downstream mattress.

As these articulated mattresses do not form a continuous slab, there is a certain amount of leaching of fine sand through the interstices between the blocks, but this is not sufficient seriously to interfere with their protective value. Improvement in this particular aspect of the matter has been attained by the development of the roll-type flexible mattress, which is less permeable than the articulated form. This, however, would not be claimed as its major justification; its advantages lie in the relative simplicity of the launching arrangements and the fact that, as it can be unrolled in direct contact with the bottom of the river, laying is less liable to be interfered with by the action of the current. The flexible rolled mattress was first experimented with in 1943, and the first installations were made in 1946. It is not considered that practice has yet developed to the stage at which the flexible mattress will eliminate the articulated form, and both types

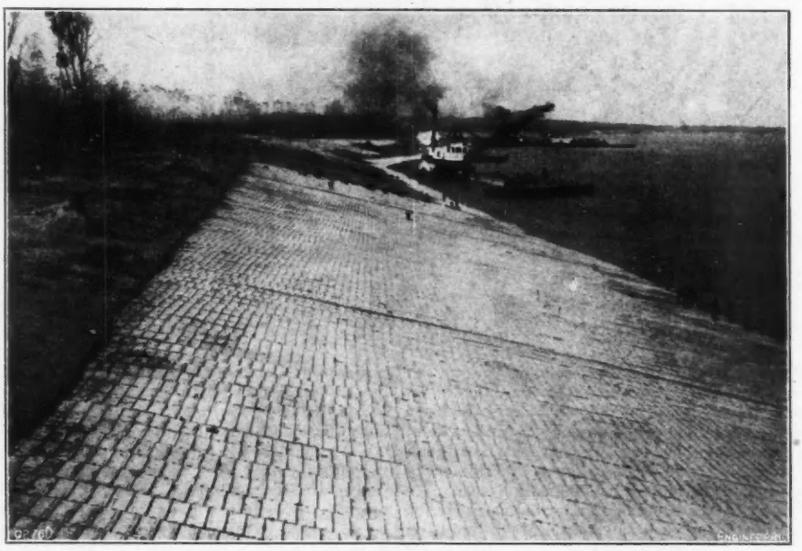


Fig. 4. Completed Bank with Articulated Concrete Paving.

are now being constructed. Practical experience with the new type is still small as compared with the old.

Flexible mattresses are made up in sections 60 ft. long and 24 ft. wide. In place of the concrete blocks of the articulated mattresses, they are made up of concrete slats 4 in. wide, 1½ in. thick and 24 ft. long, the full width of the section. The general form of the construction will be understood from Fig. 1, on page 337, which shows a mattress being rolled on to the launching drum. The slats are carried by a 2 in. by 4 in. non-corrosive wire-mesh reinforcement and the spaces between them are ½ in. wide at the top and ⅛ in. wide at the bottom. The sections are cast on the flat in forms made of wall-board. Light metal angles are fastened across the forms, at 16-in. centres, to serve as chairs for the reinforcing mesh and as spacers for removable metal grids which form the 4-in. slats. The forms are filled from dump trucks, the concrete is raked to the correct thickness, and vibrated. After initial set, the grids and angles are removed and the mattress is left for some days to cure. It is then rolled on a wooden core, 17 in. in diameter, and secured with steel tape. A rolled 60-ft. section is about 3 ft. in diameter and weighs about 8 tons.

A supply of rolled sections is built up in the stockyard and as required they are transported by barge to the scene of laying operations. They are easily handled by crane. For laying, the flexible mattresses are re-wound on to a steel launching drum, 8 ft. in diameter. This operation, which is illustrated in Fig. 1, may be carried out on the bank in the neighbourhood of laying operations or on the deck of a barge. A number of mattresses may be connected together, during this re-winding operation, to make up any desired length of finished mattress. The men shown in Fig. 1 are connecting two sections together. The launching drum is rotated on a stand by an oil engine. When it has been charged, it is lifted on to a U-shaped pontoon, which can be seen in the foreground

on the right-hand side of Fig. 2, opposite. This pontoon is moored alongside a string of barges which controls its position. The mattress is then anchored at the shore end and a spreader bar is fastened to the drum axle for unrolling the mattress into the river and retrieving the empty drum. When all connections have been made, the launching drum is released from the U-shaped pontoon and the mattress is unrolled as the drum rolls along the bottom of the river. The drum is then drawn back to the shore for re-charging and the whole equipment is moved 12 ft. upstream for laying the next mattress. As the mattresses are 24 ft. wide, this procedure gives an overlap of 12 ft. and a double mattress thickness throughout, with a consequent closer approach to impermeability.

The photograph reproduced in Fig. 3, opposite, gives an indication of the arrangement of the spreader bar used to unroll the mattress. This figure, however, does not refer to the normal arrangement which has been described. It shows an emergency operation which was carried out in the spring of 1946, on a 3,000-ft. length of caving bank on the Red River. As conditions were rapidly deteriorating, there was no time to assemble the proper launching equipment and mattress sections were unrolled from the shore by the spreader bar shown, which was attached to a cable leading to a pulley on the other side of the barge partly visible on the right. The mattresses checked the rapid erosion, but did not form a satisfactory permanent revetment. They were later found to be broken, apparently during the improvised launching, and later became badly undermined.

The articulated form of revetment has been used for the protection of the upper part of river banks, as well as the underwater portion. Upper bank paving is clearly the simpler problem of the two, and various arrangements have been devised and employed. It is normally possible to eliminate gross irregularities in the bank by some form of land grading and so to facilitate paving. Monolithic concrete paving was laid as long ago as 1900, and ten years later reinforced monolithic work was introduced. Later experience showed that the reinforcement was not necessary and practice settled down to a monolithic concrete slab 4 in. thick and with expansion joints 100 ft. apart. It is considered that monolithic paving is less subject to damage by drift material and current action than any other type, but on banks subject to settlement, maintenance costs may be high. In recent years, a considerable area of bank has been laid with articulated pavement, which is comparable in first cost with monolithic construction and is cheaper to maintain.

An example of upper bank articulated concrete paving is illustrated in Fig. 4, opposite The bank is graded and covered with a 4-in. thick blanket of gravel. The lower sections of the mattress are placed in position by a floating crane and the upper by a crane located on the top of the bank, or are pulled up the slope by a tractor. The anchor cables of the under-water mattresses are used as far as possible in the anchoring of the bank sections. The openings at the joints between the 25-ft. sections are grouted to prevent the leaching out of fines from below the pavement. One of the advantages of the articulated-mattress paving as compared with monolithic work is that delays owing to inclement weather are greatly reduced, the sections being cast and cured well in advance. Another valuable feature is the speed of operation; the bank pavement can usually be installed within a day after the completion of the under-water work. This is an important matter as a sudden rise in river level might overtop and damage, or destroy, the upper portion of the subaqueous mattress before it was connected to, and protected by, the bank paving.

A further method of protecting river banks which has been developed within recent years may be mentioned, although it does not strictly fall within the subject of this article. The method is described in the October, 1946, issue of *Civil Engineering*, the journal of the American Society of Civil Engineers, in an article contributed by Lieut.-Col. A. B. Pickett. The method has been developed in view of the success of a test installation made in the vicinity of New Orleans in 1943. The river bank was coated with a mixture consisting of 55 per cent. of washed concrete gravel, 38 per cent. of washed sand, and 7 per cent. of 40/50 asphalt cement. The bank was graded to a slope of 1 vertical to 3 horizontal, but the surface was not prepared in any way other than the removal of drift material and the smoothing of major irregularities. The mixture was applied at temperatures of 300 deg. to 350 deg. F. by a one cubic yard clamshell bucket and raked down to an average thickness of 6 in. The material was found to flatten out naturally after dumping, and required but little raking. Since its completion, this paving has successfully stood up to wave action and passed through a major flood in 1945. It shows no sign of failure or deterioration.

This installation was followed up by one on the Mississippi River in which asphalt concrete was used to bind a heavy blanket of stone rip-rap and by a third in which an upper-bank asphalt pavement was laid on a section of river protected by flexible under-water mattresses. The exposed bank was very soft and, as it was desirable that seepage water should percolate through the pavement, a mixture of 94 per cent. sand and 6 per cent. of asphalt cement was used. It was found that there was slow percolation, as had been desired and expected. It is claimed that this method of bank protection has the advantages that approximately 95 per cent. of the material used can be obtained locally from the river, that the mixture can be placed and spread quickly by a small crew with ordinary construction equipment, and that no forms, screeds or expansion joints are necessary. An investigation has been carried out at the Vicksburg Experiment Station to determine the effect of mixing temperature on flexibility, and the effect of asphalt content on flexibility and porosity. A specification has been drawn up and a considerable number of asphalt pavings have now been laid in conjunction with under-water concrete mattresses.

LITERATURE.

Jigs and Fixtures for Mass Production. By LELAND A. BRYANT and THOMAS A. DICKINSON. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 25*s.* net.]

EVERY mechanical engineer is aware that the development of jigs and fixtures has made possible the manufacture of large numbers of replicas of a component with a uniform degree of accuracy in relation to the nominal dimensions, and that it is this ability to reproduce accurately, rather than to make accurately, which has been the foundation of mass production. Jigs and fixtures are, indeed, a parallel invention to the printing press, and, if they had been invented all at once, they would probably be recognised by all men as constituting a revolution as profound in its effects as the introduction of printing. Perhaps, too, it would be appreciated by society in general that, like the art of printing, mass production introduces a new craft, not entirely in place of, but based on, that of the individual making by hand a single object. The subject is worthy of a treatise, therefore, historical in its approach, in which the application of simple principles is traced step by step, showing how each new step extends the power of the engineer to make more intricate objects, more perfectly, and even, by so doing, to make machines that otherwise would have remained an impracticable dream.

Emphatically, this book is not such a treatise, yet, to the informed reader, it is quite exciting by the vistas which it opens up in describing and illustrating some of the most modern developments of jigs and fixtures. The authors claim that the text will be understandable both by the beginner and by the expert; but a mere glossary of terms is not enough to reveal elementary principles to the uninitiated, and it must be said that the book is a typical product of the practical expert who has lost the power to put himself in the position of a reader outside the subject. The chapters devoted to the more usual types of jigs and fixtures are profusely illustrated, but the explanations are mostly meagre. The authors are experts who proudly display their equipment, happily unconscious of the fact that the admiring reader wishes to ask a thousand questions, the first of which would reveal that he has not a clue to the object displayed to him. It must be added, indeed, that some of the photographs will be puzzling, even to the expert. For him, however, the book will be full of stimulating examples, and two or three experts putting their heads together, will get new ideas from these in whatever field of production they may be engaged.

The highlight of the book, however, is undoubtedly the chapter on the "master tooling dock." Developed originally as a positioner for the locating elements of assembly jigs or fixtures for complex streamlined structures such as aircraft, it is really the logical end of all jigs and fixtures; that is to say, a complete building which is itself a "jig" and within which all operations affecting finished dimensions may be performed. The background of the book is the American aircraft industry, but there are already examples of the principle of the master tooling dock, in more limited form, in other industries which are not so developed in mass-production methods, such as the jigs used for making locomotive frames. This chapter will be most valuable in showing the immense possibilities of developing this principle. There is an up-to-date chapter also on the use of plastics for making jigs and fixtures. It is to be regretted that so much space is taken up in reprinting American standards, which might have been omitted in an English edition, but, with all its faults, no one engaged on the design or use of jigs and fixtures will regret a close study of the book.

Line of Communication. Railway to Victory in the East. By JOHN THOMAS. The Locomotive Publishing Company, Limited, 88, Horseferry-road, Westminster, London, S.W.1. [Price 6*s.*]

THIS little book is valuable because it deals with a remarkable feat of railway operation in a theatre of war of which the public were hardly conscious until, towards the closing stages the "Forgotten Army" was remembered. The lines of communication for British forces in South East Asia, through Bengal and Assam to Burma, passed through such primitive country, and were so remote even from military headquarters in Delhi and Ceylon, that the railway and road transport units operating over them ploughed a lonely furrow and never received the public recognition that was their due.

It is therefore easy to appreciate the feelings of the small band of British and Indian railway-operating troops when United States troops, taking over in certain sectors, were accompanied by a publicity service which was doubtless normal by American standards, but excessive by British. Mr. Thomas endeavours to give due credit in each case, and quotes an American colonel to show that our Allies recognised the pioneer work which had been done before they arrived. British and Indian troops, in small numbers, supplemented the civilian railway staffs, and often shouldered responsibility far beyond their experience. By comparison, there seemed to be no shortage of man-power in the United States units, and they were also fortunate in arriving on the scene when new equipment was being received. Nevertheless, American troops did not suffer from the respect for Indian traditions and habits which undoubtedly hindered British work, and accordingly they regarded railway operation as a branch of warfare in which everything not directly connected therewith was of no importance. The transport systems of India, indeed the whole defence of the country, had been organised on the assumption that war would come from the west. An invasion through Burma had hardly been considered, and, when it came, a metre-gauge single line, with a bottleneck consisting of a small wagon ferry across the Brahmaputra, had to be developed until it carried 7,000 tons of military stores a day.

Sabotage, famine, floods, serious lack of rolling stock, and the "jitters" among the native staff, added to the problems. The disturbances which followed the imprisonment of the Congress Party leaders in 1942 caused widespread damage and dislocation of traffic, and the cost to the railways of India was estimated at Rs. 42,00,000. In 1943, the river Damodar, in Bengal, burst its banks and destroyed 16 miles of track of the East Indian

Railway's two main routes to the Calcutta base. Despite a complete absence of local labour and materials, a diversion, partly on embankment and partly on heavy steel bridges supported on wooden piles, was constructed in 82 days. In due course, the original bund was restored, but a substantial bridge diversion was constructed, so that in time of serious floods it would be possible deliberately to breach the bund to allow the flood-water to disperse; the diversion was to be used until the floods had subsided and the artificial breach could be repaired. Mr. Thomas's account will be a useful contribution to the records of the most difficult line of communication of the war. It does not, however, detract from the value of the work done by the railways in South East Asia to remark that air transport of men and materials to forward positions was developed to a remarkable extent in that theatre of war.

The Atom and Its Energy. By Professor E. N. da C. Andrade. G. Bell and Sons, Limited, York House, Portugal-street, London, W.C.2. [Price 10*s.* net.]

The problem with which this book deals is of vital concern to everyone. Should the scientific spirit of international co-operation prevail, atomic energy promises benefits likely to revolutionise industry, science and medicine. Should national rivalries lead to an atomic armaments race, the prospects for the survival of civilised society are slender and Professor Urey's warning, that "the next war will be fought with atom bombs and the one after that with spears," is likely to be no idle one. The physicist is deeply conscious of the issues at stake and fully alive to the imperative necessity of enlightening the politician and the ordinary citizen concerning the situation created by his efforts. Few men are as well qualified as Professor Andrade to present the implications and applications of these recent developments in physics to the general reader. Apart from his acknowledged authority as a physicist, he has already proved himself a master of the art of vivid description, telling illustration and lucid exposition.

The earlier part of the book outlines the evidence for the atomicity of matter, electricity and radiation, and traces some of the consequences that follow therefrom. It incorporates in revised form much of the material originally published in his book in Benn's Sixpenny Library under the title of *The Atom*. The last two chapters, on the transmutation of the atom and the release of atomic energy, are new. They bring the story up to date by relating the tremendous strides made possible by the concerted attack of teams of experts, backed with unlimited funds. The atomic theory of matter was formulated scientifically by Dalton at the beginning of the Nineteenth Century, the electron was recognised and its specific charge measured by J. J. Thomson at its end, while the quantum theory of radiation was originated by Planck at the beginning of the present century. Professor Andrade does not confine himself to recounting results; he indicates the means whereby the results were achieved. He describes, for instance, Millikan's classical determination of the electronic charge, Wilson's fundamental development of the cloud chamber for rendering the tracks of individual charged particles visible, and Aston's pioneer work on isotopes with his mass spectrograph. Such examples afford excellent illustrations of the method of physics. They show how simple experiments may be made to yield remarkable results in the hands of imaginative and experienced investigators and how the theories of the atom are based on careful measurements of experimentally-controlled phenomena.

Almost the simplest of all experimental techniques was that whereby Rutherford, in 1919, made the first observations of artificial transmutation. The apparatus consisted of an α-particle source housed in a gas chamber with a fluorescent screen at one end and a low-power microscope to observe the scintillations. With it, the decisive result was obtained. The next stage consisted in the design of machines to accelerate nuclei and render natural radioactive sources obsolete. With the most celebrated of these—the cyclotron—the principle of which is explained, particles with energies corresponding to 16 million volts have been generated in numbers equivalent to the output of 30 tons of radium. Another powerful agent for transmuting atoms is the neutron, and the different effects of swift and thermal neutrons are well brought out. The atoms resulting from transmutation may be either stable or radioactive and the energy transactions involved in the process are clearly described in terms of the Einstein mass-energy equivalence relation. Following an account of the fundamental discovery of uranium fission by Hahn and Strassman in 1938, the intricate chemical and physical problems involved in the construction and operation of the atomic pile are discussed. The horrifying climax of this vast war-time research project was the atom bomb, estimated to have wrought destruction equivalent to 20,000 tons of T.N.T.

Happily, there is a more constructive side to the picture and Professor Andrade concludes with an estimate of the prospects of converting the pile into a power generator and a summary of what has been achieved already by the use of the radioactive by-products of the pile as tracer elements. As the atom train is now on tour through the country, the appearance of Professor Andrade's book is opportune.

Steam-Engine Builders of Norfolk. By Ronald H. Clark, A.M.I.Mech.E. Augustine Steward Press, Tombland, Norwich. [Price 5*s.* 6*d.*]

The county of Norfolk is associated in the minds of most people with agriculture, and that is still true, so that it may come as a surprise to many to learn that, at one time or another, no fewer than 31 firms have been engaged in building steam engines in that county. The reason for what seems to be an anomaly, in an area lacking the raw materials for engine-building, may be found in the facts that the county has been in the agricultural forefront since the days of Coke of Holkham, first Earl of Leicester (1752-1842); that the mechanisation of agriculture was early practised there; and that a goodly proportion of the firms referred to made agricultural machinery. The period under review in this booklet is the latter half of the Nineteenth Century and onwards. This period saw the heyday of the reciprocating steam engine and that of the individual engineering business. To-day only nine of the firms remain in business, some merged with other firms elsewhere, and only three of them make steam engines.

The author lists the firms alphabetically and gives the history of each so far as he has been able to trace it. The location of the firms was decided, obviously, by the transport available at the time, hence nine of them were at Great Yarmouth, eight at Norwich, and four at King's Lynn; of the rest, one, or at most two, were in inland places. The oldest firm in the county was Charles Burrell and Sons, of Thetford, established by James and Joseph Burrell in 1770 but only brought into prominence by Charles Burrell about a century ago. In 1856, he took up Boydell's traction engine, the feature of which was that the wheel carried and laid its own track, known as "elephant feet," for traversing soft ground. This led on to the well-known engine for travelling showmen. Apart from this, a great variety of engines were made such as portable, semi-portable, street tram and marine engines; even iron vessels were built. A firm of some note was the Cooper Steam Digger Company, of King's Lynn, founded by Thomas Cooper to make his patent digger, which had forks in a double row transverse to the axis of the engine and behind it. The firm continues to-day as the Cooper Roller Bearings Company. Savages, Limited, of King's Lynn, established in 1850 by Frederick Savage, will be remembered for the part they played in the application of steam power to fair-ground machinery. This firm made the well-known Darby "broadside digger," which cultivated a width of 21 ft. at the rate of 12 yards in an hour. The author is to be congratulated for rescuing so much information that, in a few more years, might have been forgotten, and for recording for one county what was a significant period in British industrial and economic history. It is a pity, though, that he refers to a traction engine as a "traction" throughout the book. The fact that it is common usage among the drivers of such machines is no good reason for its acceptance in print.

THE INSTITUTE OF METALS.

(*Continued from page* 329.)

We continue our report of the annual meeting of the Institute of Metals, dealing with the last paper presented on March 17, and with the first taken on March 18.

Young's Modulus of Aluminium Alloys.

The second paper taken on the afternoon of Wednesday, March 17, dealt with "The Young's Modulus of Some Aluminium Alloys" and was by Mr. N. Dudzinski, Miss J. R. Murray, Mr. B. W. Mott and Dr. B. Chalmers. An appendix by Mr. S. F. Grover, Mr. W. Munro and Dr. B. Chalmers dealt with "The Moduli of Aluminium Alloys in Tension and Compression." The paper describes work done at the Royal Aircraft Establishment, Farnborough, Hampshire, and was presented by Miss Murray. The authors stated that various binary, ternary, and complex aluminium-base alloys had been prepared with a view to investigating the possibility of increasing their Young's modulus, E. All the five elements investigated had been found to enhance the value of E, manganese having the greatest effect (about $0{\cdot}34 \times 10^6$ lb. per square inch for each 1 per cent. by weight) and the elements beryllium, cobalt, nickel and silicon were found to have a decreasing effect in that order. Beryllium and cobalt both had a greater effect in the presence of 12 per cent. silicon than in the respective binary alloys, but the effect of beryllium was smaller in alloys containing 2·5 per cent. of copper. Attempts to relate these effects with the constitution of the alloys had met with only partial success. The values of E obtained on forged and heat-treated aluminium-nickel and aluminium-silicon alloys were in agreement with those given by corresponding alloys in the chill-cast condition. On a complex aluminium alloy containing silicon 12, copper 2, nickel 2, manganese 1, magnesium 0·6, cobalt 0·2, and titanium 0·05 per cent. (with the exception of sand-cast and thin sheet materials), the value of E was the same, within experimental error, for materials in the cast, forged, and rolled conditions, both before and after heat treatment. The somewhat lower values obtained for sand-cast material was probably due to porosity which was usually present in sand castings. The reasons for the low values for thin sheet were considered to be related to difficulties of obtaining accurate extensometer measurements on thin, flat test-pieces.

There were possibilities of developing alloys combining high strength with improved Young's modulus. Although no effort had been directed towards this end, the indications were that, by suitable modifications of composition, alloys could be produced having the following tensile properties; 0·1 per cent. proof stress, 21 tons per square inch; maximum tensile stress, 28 tons per square inch; elongation, on $4\sqrt{A}$, 4 per cent.; and Young's modulus, 12×10^6 lb. per square inch. It was considered that it would be possible, as a result of further work, to produce alloys having a Young's modulus greater than 12×10^6 lb. per square inch, without any marked lowering in the tensile properties. The appendix described tests designed to determine whether, for aluminium alloys, the Young's modulus in tension was the same as that in compression. Two materials had been used: one in the form of bar, to British Standard Specification No. 6L1, and the other in the form of sheet, to specification D.T.D. No. 646A. The results indicated that, within the limits of experimental error, the moduli in tension and compression were the same.

Professor L. Aitchison said that the authors had not done full justice to the mechanical properties of these alloys. They had suggested that it was possible to obtain alloys having an increased modulus only by the sacrifice of other mechanical properties. That might or might not be true, but he would like them, if they could, to deny the implication because it was possible for it to be carried too far. In any case the properties described in the paper were sufficiently attractive to aircraft structural engineers, and metallurgists must take full notice of the development. Very active co-operation

by industrial manufacturers of alloys appeared to be called for, so that the ideas and concepts whereby our metals could be built up from their elements, and not just taken as they came, could be carried farther and put to practical use, particularly for structural-engineering purposes. Finally, he desired to know whether the authors could assure the engineering world that it could be assumed that the rigidity modulus went in parallel with the elastic modulus.

Dr. G. V. Raynor said that it was most unlikely that any significant improvement over the values already secured by the authors could be obtained by the addition of any pure metal which did not form intermetallic compounds with aluminium. It seemed, therefore, that inter-metallic compounds must be relied upon to give any possible improvement. Unfortunately there were very few data indeed for the Young's moduli of intermetallic compounds which could be used as a basis for choice. He agreed, however, that the heat of formation of an inter-metallic compound could be taken as a measure of the Young's modulus for the purpose of selection. Qualitatively speaking, the higher the heat of formation the tighter would be the binding between atoms, and, therefore, the higher the Young's modulus might be expected to be. Dr. H. Sutton, who spoke next, said that one interesting feature of the work was the apparent insensitivity of the authors' alloys to condition, namely the cast as compared with the wrought state, or the as-cast as compared with the heat-treated state. The next speaker, Mr. L. Rotherham, said that, on the development side, reference had been made in the paper to the work which Stalker had been doing on more complex alloys. Here quite substantial progress had been made, though there were some initial difficulties in the heat treatment of some of the alloys. It was of interest to note, however, that the final properties obtained coincided almost identically with those properties listed in the present paper. Mr. A. J. Murphy stated that, up till the present, it might be said that the exploration in this field of research had been to confirm the additive nature of the Young's modulus and to find how far it was possible to proceed by enriching alloys in high-modulus elements or compounds before the other desirable mechanical properties declined seriously. Generally, at present, elongation seemed to be the limiting factor. If, however, it were possible to find in complex alloys, that from a given addition of element more than a proportional effect on the modulus could be obtained by suitable manipulation, matters would become very promising.

Mr. J. W. Jones felt that a higher E for alloys would not yield immediate results; it would produce a set of problems for technical men, who were usually somewhat conservative. He added that there appeared to be little attraction in alloys which were less strong but had a higher E than those now in use, because the question of breaking stress as well as bending stress arose. He noted that a projected alloy now being developed contained nickel, copper, and other elements. Any increase in the specific gravity of an alloy to be used in an aircraft structure was significant, and, for that reason, it appeared more advantageous to give attention to materials containing beryllium, alloyed, perhaps, with 10 per cent. of silicon, rather than aluminium alloyed with manganese, copper and nickel.

Mr. N. Dudzinski, in reply, said that French investigators had shown that the value of the modulus of rigidity increased in a manner similar to that of Young's modulus. The suggestion had been put forward that heat treatment of the beryllium-copper alloys would prove to be beneficial. It had been shown in France that with up to 15 per cent. of beryllium a considerable increase in Young's modulus was obtained, and the modulus of that alloy was higher than that of steel. Unfortunately, not much was known regarding differences in the Young's modulus of steel with variations in the percentages of carbon present. Mr. Jones was interested in the question of whether aluminium-beryllium could be used; he had suggested material alloyed with 10 per cent. of silicon. The density of such an alloy would be favourable, but much could not be expected from that system because aluminium-silicon did not form any inter-metallic compounds with aluminium; and beryllium did not form any either. It had been proved, moreover, that if too much beryllium were added to aluminium, the mechanical properties deteriorated instead of improving.

At this stage, the President adjourned the meeting until 10 a.m. on the following day, for the fourth and final session of the meeting. This was held on Thursday, March 18, and the chair was occupied by the President, Sir Arthur Smout.

Pressure and Creep Tests on Lead.

The first paper on the agenda dealt with "Pressure and Creep Tests at Constant Hoop Stress on Lead and Alloy-'E' Pipes." It was by Dr. A. Latin, of British Insulated Callender's Cables, Limited, London. When presenting it, Dr. Latin stated that a wide range of tests in connection with pressure-cable sheath problems was in progress in his firm's research laboratories at Wood-lane, on lead and lead-alloy pipes subjected to internal pressure, the pressure being maintained constant for each test. The materials used in the investigation were high-purity lead pipe and alloy-"E" pipe, an analysis of which gave: tin, 0·386 and antimony, 0·253 per cent. In the constant-pressure tests, the mean diameter of pipe samples, usually yards in length, was determined, the pressure, corresponding to a desired original hoop stress, being kept constant and diameter-tape measurements being taken at intervals until the sample burst. Some of these tests, at very slow creep rates, had been in progress for more than 10,000 hours. The type of creep curve obtained for these tests was similar to that for creep of wire and strip under constant load. An initial rapid extension was followed by a slower extension, in most cases at a nearly constant rate, the final rapid extension taking place locally at the point of failure.

From the results obtained, the constants β and k, in the Andrade equation for creep at constant applied stress, had been determined. These two constants were considered to represent two different types of creep flow. The results would appear to throw some light on the "extensibility characteristics" disclosed by the constant-pressure tests. These showed a greatly diminished extension before fracture for alloy "E," but not, so far, for pure lead at slow creep rates. The Andrade equation for creep at constant applied stress was:

$$l_t = l_0 (1 + \beta t^{\frac{1}{3}}) e^{kt},$$

where l_t = length of specimen after time t; l_0 = a constant which, in the present tests could be taken as the original length of the specimen; β = a constant associated with the so-called "grain-rotation" type of flow. This was often called transient flow, or β-flow, and appeared to be dependent on a rotary motion occurring within the crystal grains or, more accurately, grain fragments. It was considered to result essentially from the process of glide-plane slip. Finally, k = a constant, representing a type of flow considered to differ (perhaps fundamentally) from β-flow. Failures in pressure-cable sheath of certain alloys might be connected with these effects and possibly also with effects, of a fundamentally similar nature, due to stress relaxation. The influence of grain size needed further study, and grain refinement might prove to be of great importance, if carried out in a suitable manner.

The discussion was opened by Professor E. N. da C. Andrade, F.R.S., who stated that whether or not rupture occurred as a result of flow in a material depended on whether the material hardened or not at a point where thinning occurred. Glass could be blown because when the material began to get thin it cooled and the thinner portion hardened. It would be impossible to "blow" lead at, say, 250 deg. C., at which there was hardly any hardening and only k-flow occurred; the material would rupture at once. He imagined, therefore, that what was favourable for non-local rupture was a good deal of hardening and a good deal of β-flow. The author had said that the formula was probably not universally applicable. He (Professor Andrade) had verified it, using lead, copper (face-centred), cadmium (hexagonal) and mercury (rhombohedral), and Orowan had found that it applied to aluminium. It was, therefore, applicable to a very wide range of metals at a wide range of temperatures and stresses, but not if crystallisation occurred.

Dr. J. McKeown said that in most of the previous work carried out at constant stress, the stress employed was unidirectional, whereas in the present work each element, particularly at the inner surface of the lead pipe, was subjected to a three-dimensional stress system, so that the author was really working under combined-stress conditions. It was necessary to recognise this difference. There was a possibility that the presence of the longitudinal stress, in particular, might influence the values, and also the ratio of the β-flow and k-flow constants. Work carried out before the war in the laboratories of the British Non-Ferrous Metals Research Association had shown that, in pure lead, the smaller the grain size the greater the extension at fracture. Moreover, in any one lead alloy the finer the grain size the faster the rate of creep in the second stage. Metallurgists were, therefore, confronted with two conditions, namely, a fine grain giving a rapid rate of creep coupled with considerable extension at the fracture, and a coarse grain giving a slow rate of creep coupled with small extension at the fracture. Each condition was suitable for certain applications.

Dr. J. C. Chaston referred to the general question of the value of bursting tests on lead sheath. No photographs of bursts had been included in the paper, but he (Dr. Chaston) had found that, in his tests, at room temperature, failure always occurred along the seam of the press, the sheath opening up in a long split, 8 in. or 9 in. in length. At 110 deg. C., on the other hand, the material, instead of opening up, just failed at one point. The real value of sheath bursting tests was to obtain data on the performance of the sheath in service, and, as such, they were invaluable to cable engineers. Without a good deal of further evidence, however, they should not be regarded as evidence on which theories of creep failure should be based. Dr. E. Orowan, F.R.S., who spoke next, stated that the most outstanding point in the paper was the variation of the uniform extension with the rate of creep. The extension involved was a uniform one, as distinct from the neck extension in tensile tests. For alloy "E" the uniform extension was very large at high rates of deformation and became very small at low rate of deformation, while, in the case of lead there was fairly irregular scatter between 3 per cent. and about 12 per cent. uniform extension.

In a brief reply, Dr. A. Latin said that the scatter in the tests had been very considerable, but the mean of a very large number of results had been taken for the purpose of establishing data. One point regarding necking required some emphasis, namely, that a very large number of pipes failed, after a long period of time, with intercrystalline cracking and no very definite local necking, even in the case of pure lead.

The discussion on the last paper taken will be dealt with in a subsequent issue.

(To be continued.)

THE FAN MAKERS ASSOCIATION, LIMITED.—At a luncheon of the Fan Makers Association, Limited, held at the Connaught Rooms, London, W.C.2, on Tuesday, March 16, Mr. N. Burke, the retiring president, outlined the aims and work of the Association, and announced that Mr. D. S. Woodley had been appointed President for the present year. Mr. Burke stated that 15 leading fan manufacturers were now included in the Association, the objects of which were to promote the general interests of industrial fan manufacturers, and to encourage technical liaison between them. Close contact was being maintained with official bodies such as the Board of Trade, the Department of Scientific and Industrial Research, and the Ministry of Supply, regarding questions relating to standardisation and testing of fans, and the supply of steel for the industry. Although the Association had set up committees to consider commercial, as well as technical and educational matters, it was not favouring any price-fixing or cartel. The educational committee, in conjunction with other interested parties, was preparing an Association handbook, together with pamphlets on fan engineering, and was also taking steps to establish a college for the purpose of training technicians in the problems of fan technology. The secretary of the Association is Mr. G. L. Copping, 23, Queen-square, London, W.C.2.

METERING PRACTICE ON THE BRITISH GRID SYSTEM.*

By F. BYRNE.

THE Electricity (Supply) Act, 1926, created the need for new and complex systems of metering not previously developed in Great Britain; and the success of British manufacturers in meeting the exacting provisions of the Central Electricity Board's specification did much to stimulate the demand for improved metering in general. The first grid metering equipment was commissioned, in 1928 and there are now 363 installations, including 179 equipments employing electrical summation. These range from a single meter with maximum-demand indicator to an equipment with 104 impulsing meters, 15 summators and 6 printometers. They comprise 5,148 meters, including 1,123 VArh meters and 4,554 impulsing meters, as well as 863 summators and 885 demand recorders, including 112 graphers and 44 printo-graphers. The metering equipment at a selected station is arranged for the purpose of ascertaining the "adjusted station cost of production" in accordance with the Electricity (Supply) Act, 1926, and Statutory Rules and Orders Nos. 1015 and 1016, 1929. The values of the functions that are required, among others, are: the kilowatt-hours and kilowatts of maximum demand of the supply from the generating station to the undertaking and imported by the undertaking; and the power factor at the time of maximum demand. The import to the undertaking is the positive value of all the imports less all the exports at any instant, and is measured by the net import summator. The supply from the generating station, with allowances for station auxiliaries, is measured by the net generation summator. It is transmitted with the total import and total export to the undertaking summator, which measures the algebraic sum.

Both electrical and impulsing systems of summation are employed. Three methods of electrical summation are in general use, namely, paralleled-current transformers, bifilar meter series coils, and summation current transformers. Electrical summation has obvious advantages where the arrangements are simple, but it is generally impracticable when more than four circuits are involved, with the many complex grid connections and where the metering points are some distance apart. The majority of summation metering schemes used on the grid, therefore, operate on impulses initiated by the meters and inevitably involve the making and breaking of an inductive circuit. Some device for minimising contact wear is therefore essential; and these may be classified as accelerated break or spark suppression. The contact material consists of platinum, silver or special alloy. In general, direct-current impulsing is preferred, especially over long distances.

No fundamental changes in meter design have taken place during the period under review. The high-grade accuracy demanded by the grid specifications has been maintained without difficulty, although small variations have inevitably occurred in service. The chief causes of these have been brake-magnet ageing and, apart from contacts, bearing and train friction at low loads. Diamond failures have been negligible, but because of scarcity, sapphires are now permitted on all types of meter. The number of defects with these is small and the cost of renewal inconsiderable. Ratchets and pawls to prevent reverse rotation are a weak feature of most types of meter. Maximum-demand indicators have exhibited the usual inherent defects, such as backlash, tooth and reset errors; and failures have occurred owing to surface adhesion between the driving and free arms. Pointer creep sometimes occurs owing to local vibration. Most of the difficulties are due indirectly to the relatively small forces available. On the type-B high-torque meter the original ratchet-and-pawl mechanism had to be discarded owing to impulsing difficulties. The re-designed pawl tended to stick, but is now mounted on jewelled bearings. Gear trains have occasionally given trouble on the type-D meters and wear has taken place on the rotor pinion. A few faulty pawls have been noted, but have not caused reversal as they are duplicated.

Summators are essentially electro-mechanical devices and all types embody gears, differentials and ratchet-operated counting trains to a greater or less extent. Faults are mainly of a mechanical nature. The maximum-demand indicators incorporated in the summators are less susceptible to trouble than those attached to the meters, as ample driving forces are available. Type-A summators, designed for operation on direct-current, have not been so successful when converted to alternating current. Operation was noisy and vibration became so pronounced that damage was caused to the gearing. They are now being reconverted to direct-current. Re-transmitters are rather inaccessible for maintenance. The maximum-demand indicator drive is re-set by gravity-cord, pulley and weight. If the cord breaks, the shock is liable to disturb the mechanism. An oil cushion has been fitted beneath the weight, therefore, to minimise the effect. The behaviour of the type-B summator is also better on direct-current. The counting train ratchet is controlled by an escapement, which must be set carefully to avoid tooth slip. The re-transmitter is driven through a flat-coiled spring, which is designed to even out the rate of impulsing. Gear friction will cause this to wind up until there is sufficient tension to overcome the resistance. The effect is to store an abnormal number of impulses and then to transmit them erratically. A few cases of excessive wear have been found in the differential pinion bearings. Maximum-demand indicators occasionally read incorrectly owing to foreign matter between the clutch faces.

No difficulty has been encountered with the type-C summator, which has been designed to operate on alternating current; and the action is generally noiseless and smooth. A few ratcheting failures have occurred, mainly owing to maladjustment. The original construction of the type-D summator did not prove satisfactory. The impulse relays required frequent and critical adjustment and the rotary switch was troublesome. Modifications were carried out from time to time, incorporating telephone-relay chains, but the summation and impulsing systems have now been redesigned by incorporating a new contact mechanism resembling type-C. The circuit break, however, is accelerated, not by storing kinetic energy from the meter driving forces but by a magnetic impulse derived externally. The equipment is designed for direct-current or rectified alternating current. The retardation due to the contactor is negligible at normal meter loading and is of the order of 0·1 per cent. at low loads.

Demand recorders are used to assess the load on the grid and the readings are telephoned to the control centre at regular intervals. It is desirable that this should be done without having to interfere with the instrument. Visibility and printing legibility are also important. The most common fault on all printometers is illegibility due to misalignment of the type wheels during the printing operation. A tendency on one type for the chart to take the wrong path has been cured by fitting a special guard. Motor failures due to excessive brush wear and loose bearings have been dealt with by systematic overhaul. On a second type, trouble has been experienced owing to broken pivots on the spindle supporting the hammers and to poor quality rubber pads. Some wear has taken place on the phosphor-bronze bearings of the impulse armature, thus causing noisy operation, especially on alternating current. On a third type, the storage device between the summator and the recorder has been modified to overcome the tendency for late impulses to be split between two integration periods. A damping vane on the 5-minute escapement fitted to the grapher was liable to split and has been replaced by a magnetic damper.

Two requirements are defined for the measurement of maximum demand: that the period of integration shall be 30 minutes and that the incidence of that period shall be between the commencement and middle of the hour. Specification G.M. (1944) allows a mean error of 5 minutes in 30 days, or about 0·01 per cent., for self-controlled timing devices. The pendulum-controlled and escapement-controlled clocks used have average monthly variations of ±25 seconds and ±30 seconds, respectively. These clocks must incorporate a reserve feature so that time-keeping is not disturbed in the event of a temporary supply failure. Small variations in time-keeping have been noticed on pendulum-controlled clocks, if the battery voltage is not constant. The bands on the weight-driven pendulum clocks have a life of at least five years, but when they break the case is damaged. Escapement-controlled time switches were originally electrically wound by a vibrator. Trouble occurred owing to jamming and the vibrator has been replaced by a synchronous motor. These time switches require more maintenance than pendulum clocks or synchronous time switches, and in some areas a regular routine change is carried out.

It is not easy to devise a system of fault classification applicable to metering, summation and demand-recording equipment, which will cover the various types. An analysis of the different classes of faults during the biennial test period 1945-46 showed that 34·2 per cent. were due to contacts, including mechanisms, 14·9 per cent. to printing and cyclometer mechanisms, and 10·9 per cent. to general wear and tear. The most prevalent faults were those associated with the impulse summation and demand-recording equipment. Contact faults are likely to show a reduction when the modifications in design mentioned above begin to take effect. Faults in the printing mechanisms can be reduced by more careful assembly and regular maintenance.

As the construction of the grid progressed, variations in practice took place. One of the most important of these relates to the VArh metering and summation equipments, which were installed to determine the power factor at the time of maximum kilowatt demand. As at certain periods the system power factor becomes leading, giving rise to conditions the effect of which is at least as detrimental as the corresponding lagging power factor, compensating devices have had to be provided. The cost of determining the power factor, which produces only 1 per cent. variation in the tariff charges may, however, be unduly high in comparison with that of watt-hour metering and summation. Further, when conditions of leading power factor occur the VArh equipment responds incorrectly and gives false records. As a result, VArh metering has become of less importance in tariff meters, alternatives being sought in special agreements.

The grid is controlled from a national centre with seven area controls. The areas are connected by various high-voltage lines and a knowledge of the inter-area load transfer is important. Metering equipments, which measured the flow in both directions were therefore installed at the most convenient switching points and where more than one circuit was connected, the loads were summated electrically. Metering was carried out at 132-kV and later demand recorders were added printing at 30-minute intervals. It became evident, however, that control centres must be much more rapidly aware of load variations. Continuous readings are therefore transmitted over Post Office channels, the statutory 30-minutes integration period being reduced to three minutes or less. In consequence, the number of impulses is reduced and experiments have been made, with some success, to increase the rate of impulsing with only a slight increase in meter error. The schemes have been extended to the transmission of indications required essentially for operational reasons and are still in process of development.

From commercial considerations, the output of a generator must be metered at the point of delivery to the 'bus-bars, in this case the grid. The cost of metering proper is overshadowed by the cost of the associated current and voltage transformers, and there is some difficulty in attaining the desired accuracy because of the reduction in ampere-hours and the longer magnetic circuits of the bushing-type current transformers, which must be used in order to obtain adequate clearances. Consequently, the point of metering has been placed at the lower voltage side of the step-up transformers, and the meters have been calibrated to allow for losses on a mean efficiency basis. Justification for this method rests on the knowledge that the generators will be operating at a load approximating to their economic rating and that the resultant variation in transformer efficiency will not exceed 0·3 per cent. An increasing number of commercial arrangements are being made, which call for the summation of the demand at points several miles apart. For example, an undertaking may include two or more selected stations interconnected with the grid, where the group-undertaking demand is not necessarily the sum of the maximum demands at each point. When it is economically expedient, automatic impulse summation is provided to eliminate the human element and avoid the tedium of clerical summation. The cost of pilots is the limiting factor. In some cases a pilot-cable system owned by the undertaking already exists, while in others Post Office channels are used. The transmitting scheme varies according to the quality of the pilots, but the impulse supply is always direct-current. Generally, no additional equipment is required, but sometimes interposing telephone-type relays are used.

It is not easy to forecast the future trend in design, as so much depends on commercial requirements. It seems probable, however, that mechanical summation will be gradually superseded in favour of lighter equipment based on telecommunications practice. With the improvement in contact impulsing it is unlikely that electronic methods will be applied for this purpose, owing to the added complication. More attention will be paid to accessibility, so that maintenance can be carried out without undue difficulty. Designs to facilitate the extension of units, especially summators, will receive consideration. Should maximum-demand indicators continue to be used for tariff purposes, particularly where meters provide the motive power, improved performance will be necessary. It is unfortunate that no standard specification exists for this class of measuring device on which large sums of money depend. As an alternative to frequency-controlled clocks, it is possible that timing devices will be regulated by a central master chronometer, not so much to improve time-keeping as to secure synchronisation of the integration period. The automatic recording of meter readings provides opportunities for future consideration. It is only a stage further in the development of the printometer demand-recorders to adapt or extend this instrument to print the number of kilowatt-hours and maximum kilowatts supplied at the end of the month and at intervening times, if required.

* Paper read before the Measurements Section of the Institution of Electrical Engineers, on Friday, January 16, 1948. Abridged.

PEELING OF MALLEABLE IRON.

A MEETING to discuss the "peeling" of whiteheart malleable cast iron and the penetration of sulphide in the carburisation of steel was held at the London offices of the Iron and Steel Institute, on Thursday, April 8. As the name given to the defect implies, peeling signifies the breaking away of a weak surface layer when a malleable-iron casting is subjected to stress. The papers on the agenda for discussion included five contributions on the subject of peel in whiteheart irons, presented by a number of authorities on the subject, and a paper by Mr. A. Preece and K. J. Irvine, of the University of Leeds, entitled "Sulphide Penetration in the Carburisation of Steel."

In a short introductory paper, Mr. J. C. W. Humfrey stated that the defect of peel in whiteheart malleable castings occurred spasmodically in the years before the 1939-1945 war, but its presence could usually be detected in subsequent manufacture and its prevalence never reached serious proportions. Early in the war extensive use was made of whiteheart malleable castings for various military purposes, one of the main requirements being for the track links of carrier vehicles. Peel was not easy to detect by the usual works or official inspection tests, and if peeled links got into service they were a source of considerable danger, their failure in some cases leading to fatal accidents. In pre-war days, Cumberland hematite ore (sulphur 0·01 per cent.) was used as the decarburising agent, but when supplies of this became unavailable a Riff ore from North Africa (average sulphur 0·14 per cent.) was used as a substitute. It was during this period that the formation of peel became a serious matter, although even with the use of the substitute ore its occurrence was only serious with certain manufacturers. Since it was evident that high-sulphur ore was one of the main causes of peel formation, the Iron and Steel Control decided to stop supplies of Riff ore and substituted Thabazimbi ore from South Africa (sulphur 0·01 per cent.). This considerably reduced, but did not entirely eliminate, the trouble.

A fairly precise definition of the defect was given in the second paper, entitled "The Formation of Peel on Whiteheart Malleable Cast Iron," by Mr. A. Preece and Mr. K. J. Irvine. These authors stated that manufacturers were troubled by the occasional formation, during malleablising, of a film of iron sulphide below the surface of the finished casting. This sulphide film, together with a certain amount of inter-crystalline oxidation, with which it was associated, produced a weak surface layer which readily became detached from the remainder of the casting on the application of stress. Unfortunately, castings possessing this defect had a perfectly normal appearance, and great care had to be taken to prevent them from passing into service. From works observations there was general agreement that the presence of sulphur in the annealing ore played an important part in peel formation, but manufacturers differed concerning the particular atmosphere in contact with the casting which was most harmful in this respect. Some contended that the more oxidising the atmosphere the greater the tendency for peel formation, while others held the opposite view. It was thought, therefore, that a clearer insight into the mechanism of decarburisation of the iron might be obtained by malleablising specimens of white cast iron in mixtures of carbon monoxide, carbon dioxide, and sulphur dioxide, under experimental conditions in which the gas composition was accurately known throughout the process. This method of examination had proved informative and, in addition to elucidating the main problem, had indicated some interesting features concerned with the diffusion of sulphur in iron.

The results obtained had shown that the essential conditions for peel formation were the presence of sulphur in the gases and a high carbon-monoxide content. The oxide network which was invariably associated with peel formation was caused by preferential oxidation of silicon in the metal. Thus an original high-sulphur or high-silicon content in the iron would tend to give a thick peel, by virtue of the fact that they accentuated decarburisation. The preferential oxidation of the silicon to give an intercrystalline network of oxide was not an essential accompaniment to sulphur penetration, as had been indicated by experiments on plain carbon steel. As, however, malleable cast iron always had an appreciable silicon content, peeling was invariably associated with the oxide network. In a sufficiently reducing atmosphere absorption and diffusion of sulphur took place, forming a continuous band of iron sulphide beneath the surface of the iron. The depth of this band was directly related to the amount of surface decarburisation, and diffusion did not take place until this had proceeded to some extent. It had been clearly demonstrated that as peel formation required an extremely high $CO:CO_2$ ratio in the annealing atmosphere, a simple method of prevention was to be found in the use of ore mixtures containing adequate proportions of ferric oxide.

The third paper described work on "Peel on Whiteheart Malleable Cast Iron" carried out by Mr. J. S. Bowden while in the employ of the Superintendent of Technical Applications of Metals (S.T.A.M.), Ministry of Supply. He stated that peeling occurred when the malleablising atmospheres contained abnormally high proportions of carbon monoxide. These conditions could be avoided by the use of "strong" annealing ore mixtures and the maintenance of a mildly oxidising furnace atmosphere. A weak ore was one low in oxygen content and bulk density, whereas the properties of a strong ore were the converse of these. A smoky flame should be avoided and reducing conditions should not occur at any time during the anneal. Moreover, it was recommended that the sulphur content of the metal should be as low as possible. The manganese content should be relatively high, a figure of 0·4 per cent. being suggested as an upper limit. The silicon content should be kept as low as possible, consistent with ready response to malleablising. It was considered that the epidemic of peeling troubles which, in certain quarters, were attributed to the use of Riff ores was primarily due to the use of weak ore mixtures and insufficiently oxidising atmospheres in the annealing ovens employed.

The defect as seen from an industrial standpoint was dealt with in the fourth paper, entitled "Peeling of Whiteheart Malleable Iron," by Mr. G. R. Webster and Mr. A. E. Probst of the Britannia Iron and Steel Works, Limited, Bedford. These authors stated that the investigation described in their paper consisted of practical works experiments carried out during the war at a vital period of military-vehicle track-link production when the incidence of peeling was abnormal. Their results had shown beyond doubt that the high-sulphur content of the Riff ore was the main cause of peeling. The sulphur content of this ore was very inconsistent. Although the average analysis of a wagon varied between 0·12 per cent. and 0·2 per cent., the sulphur content of some hand-picked pieces of ore was as high as 5 per cent. Peeling would not have disappeared so long as this ore had to be used in malleablising, although the extent of the peeling could be reduced by diluting the spent ore with granite chippings.

The fifth and last paper was by Mr. J. Bernstein and dealt with "Experimental Work carried out at the British Cast Iron Research Association." Mr. Bernstein stated that the experiments conducted had again confirmed that peeling occurred only when the annealing ore contained appreciable amounts of sulphur. Under these conditions the following factors had been found to influence the severity of the peeling and the depth of sulphide penetration when a wide range of chemical compositions had been considered. In the first place, the higher the actual sulphur content of the ore, other conditions being the same, the deeper was the peel. Secondly, the higher the ratio of manganese to sulphur in the metal, the lower was the tendency to peel. Thirdly, the higher the silicon content of the metal the greater was the tendency to peel, and, fourthly, the higher the initial carbon content of the metal the lower was the tendency to peel. Factors favouring the formation of peel also increased the depth of the peel and the sulphide penetration when peeling occurred. Other variables, such as ore strength, time of annealing, and annealing temperature influenced peeling.

The final paper on the agenda, although not on peel in malleable iron, dealt with the allied subject of "Sulphide Penetration in the Carburisation of Steel." As previously mentioned, it was by Mr. A. Preece and Mr. K. J. Irvine, who stated that their results had shown that sulphide penetration into steel under carburising conditions involved first the formation of a molten sulphide on the surface which entered the metal as such by virtue of the fact that it dissolved iron on one side and rejected it on the other. The fact that the penetrating layer must be molten fixed the lowest temperature for penetration at the melting point of the iron/iron-sulphide eutectic, namely 985 deg. C. When the sulphide band was formed in the presence of oxygen, the lowest temperature for penetration dropped to 960 deg. C. and, with high-silicon steels, the sulphide band was associated with internal oxidation. The general effect of carbon, manganese, and silicon in the iron was to decrease the rate of penetration. These elements increased the degree of dispersion of the sulphide band and when this reached a stage at which the latter no longer presented a barrier to the carbon, penetration of the sulphide ceased. The results also showed related effects between the three elements carbon, sulphur, and oxygen, and the rapid diffusion of sulphur to regions high in oxygen might offer guidance in solving problems concerned with the overheating of steel. The work had now been extended to include non-ferrous metals and penetrating compounds other than sulphides and the results obtained would be published at a later date.

ANNUALS AND REFERENCE BOOKS.

Directory of Shipowners, Shipbuilders and Marine Engineers, 1948.—While there are no changes of note in the arrangement of the 1948 edition of this very useful reference book, compared with that of a year ago, the amount of detail revision that its publication has entailed is heavy as a result of the continuing post-war changes in the ownership and names of the immense number of ships built during the recent war. Presumably, this exceptional condition is likely to continue for some time yet; and, of course, there will be further changes to record in the next volume as a result of the nationalisation of the British railways. For the rest, it may be stated that all the usual features appear, and that the revised order of contents which was adopted last year has now been adopted as standard. The price has increased, however,—and understandably so—from the pre-war figure of 20*s.*, which was still maintained until a year ago, to 30*s.* net. The volume, which is compiled under the direction of the editor of the *Shipbuilding and Shipping Record*, is obtainable from the Directory Publishing Company, Limited, 33, Tothill-street, London, S.W.1.

City of Birmingham Handbook.—After a lapse of seven years, the first post-war edition of the *City of Birmingham Handbook*, compiled by Mr. F. W. Bradnock, M.B.E., public relations officer of the Corporation, has been issued. It is intended to enlighten the Birmingham citizens regarding the multifarious activities of their City Council and to illustrate to the world the growth, development and present position of Birmingham. An interesting first chapter traces the history of the City from the "Bremingeham" of the Domesday Book to modern times, and a second chapter, "An Introduction to Civic Management," explains briefly the nature and functions of the City Council. Subsequent chapters contain detailed accounts of the social services, civic undertakings and general amenities of Birmingham. Plans for new developments, which are to be proceeded with when circumstances permit, include an inner Ring Road, which will materially improve traffic conditions in the centre of the City, a new central market covering an area of 6,000 square yards, a six-storey civic restaurant building, and a new water reservoir in the Elan Valley, Wales, involving the construction of a dam to impound over 10,000 million gallons of water. Copies of the *Handbook*, price 2*s.* 6*d.*, or 3*s.* postage included, are obtainable from the City of Birmingham Information Department, Council House, Birmingham, 1.

South African Mining and Engineering Year Book.—The 38th annual edition, that for 1947-48, of the *South African Mining and Engineering Year Book*, (incorporating the *Rhodesian Mining Year Book*), is now available. It is divided into three main sections, namely, a South African section, a Rhodesian section, and a directory section. The South African section contains a detailed review of, and guide to, the mining and allied industries of the Union. The Rhodesian section covers adequately the operations of mining concerns in Southern and Northern Rhodesia, South-West Africa, Kenya and Tanganyika. The directory section provides data, including the names, addresses, activities, names of directors, etc., of mining, industrial and financial companies in the regions covered in the first two sections; particulars of overseas manufacturers having representatives in South Africa; classified lists of suppliers of the many varied requirements of the engineering, constructional and metal trades; and lists of consulting engineers and geologists in the Union and the Rhodesias, and of mining, municipal, railway and industrial buyers of plant and equipment. The year book is published by the South African Mining Journal Syndicate, Limited, 201-207, Jubilee House, Simmonds-street, Johannesburg, and is obtainable, price 2*l.* 5*s.*, postage included, from Argus South African Newspapers, Limited, 85, Fleet-street, London, E.C.4.

UNITED KINGDOM PRODUCTION OF COPPER.—Statistics issued by the British Non-Ferrous Metals Federation indicate that 25,826 tons of unalloyed copper, 28,715 tons of copper alloys and 2,654 tons of copper sulphate were produced in February. The total consumption of copper involved was 45,720 tons, of which 28,939 tons was virgin copper and 16,781 tons was obtained from scrap.

"OPERATION SIROCCO."—We have received from Messrs. Davidson and Company, Limited, Sirocco Engineering Works, Belfast, a copy of a brochure, with the above title, describing their work during the recent war. In addition to their normal products, the firm made many special items, including propellers for torpedoes, parts for tanks and guns, mooring buoys, and large numbers of valves for use in naval vessels. One of the biggest of their war-time contracts was the provision of air-conditioning plant for the underground factory of the Plessey Company, constructed in 5¼ miles of tube-railway tunnel on the outskirts of London.

2-6-0 FREIGHT LOCOMOTIVE; L.M.R.

MR. H. G. IVATT, M.I.MECH.E., CHIEF MECHANICAL ENGINEER.

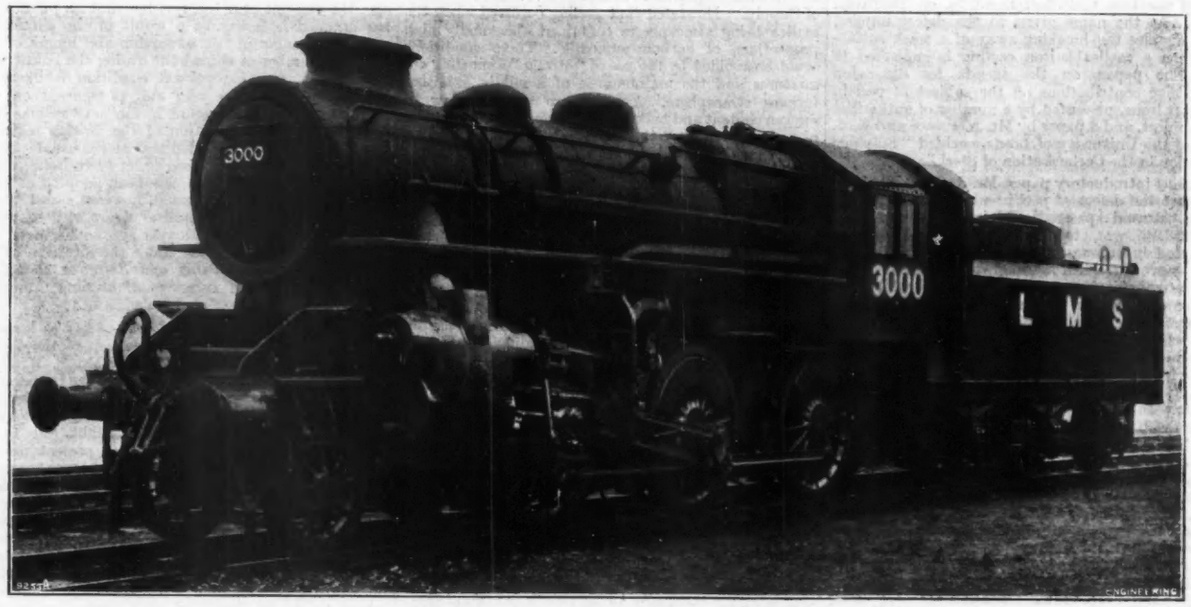
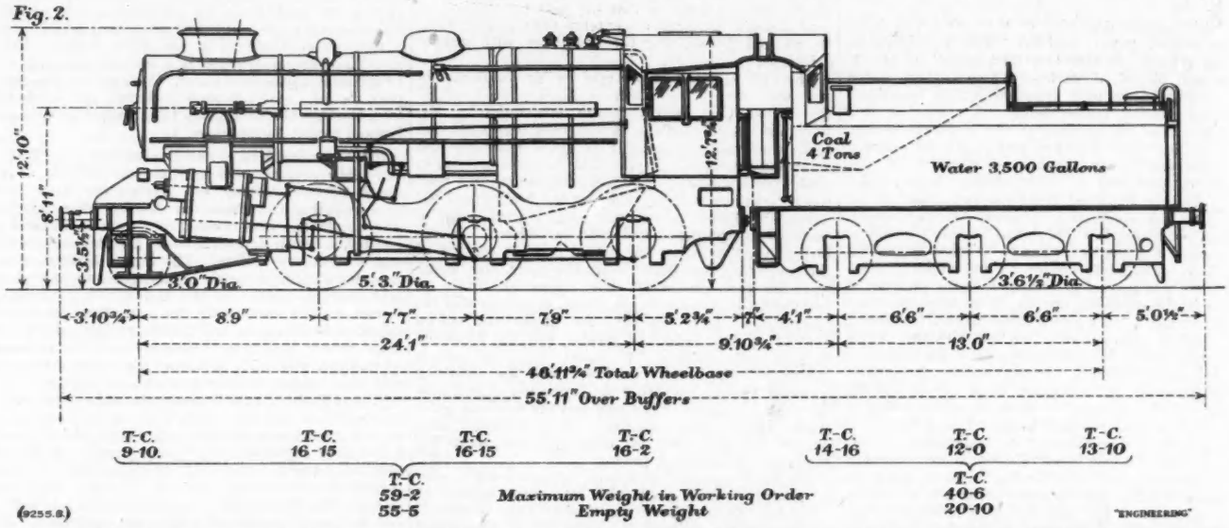


FIG. 1.

Fig. 2.



2-6-0 FREIGHT LOCOMOTIVE; LONDON MIDLAND REGION.

THE London Midland Region have recently introduced a new design of 2-6-0 freight locomotive with several interesting features; twenty, numbered 3000 to 3019, are being built at Horwich Locomotive Works, to the designs of the Chief Mechanical Engineer, Mr. H. G. Ivatt, M.I.Mech.E. The first is illustrated in Fig. 1, on this page, and the principal dimensions are shown in Fig. 2. On a recent Press visit to Crewe Works, to which the locomotive had been brought for the occasion, we were able to examine it alongside the three versions of the Class 5 4-6-0 locomotive described on page 272, *ante*.

The new 2-6-0 locomotive is rated Class 4F, which means that it is a general-purpose freight engine of medium power. It replaces, as a standard design, the late Sir Henry Fowler's Class 4F 0-6-0 freight locomotives with Stephenson valve gear, which have met requirements for engines of this power for many years. The Midland Railway introduced the first of them in 1911, and at the present time there are 772 in service. Although they have given, and are giving, excellent service, they have certain disadvantages in comparison with modern designs. In particular, it has been found that, with inside cylinders, there is a greater tendency for axleboxes to run hot. With inside cylinders and a 0-6-0 wheel arrangement, the forces on the axleboxes are severe, and maintenance is more difficult than with outside cylinders. The new design has therefore been based on a 2-6-0 wheel arrangement, which will give better riding qualities, and outside cylinders with Walschaerts valve gear.

The taper boiler works at a pressure of 225 lb. per square inch, and the area of the grate is 23 sq. ft. The barrel is 10 ft. 10⅛ in. in length, and the outside diameter is 4 ft. 9½ in. at the smokebox end, and 5 ft. 3 in. at the firebox end. The firebox is 7 ft. 6 in. long by 4 ft. 0½ in. wide. There are 24 superheater-flue tubes, 5⅛-in. outside diameter and 7-s.w.g. thick; 24 superheater elements 1½-in. outside diameter and 11-s.w.g. thick, and 160 small tubes 1⅝-in. outside diameter and 12-s.w.g. thick; the distance between the tube-plates is 10 ft. 10⅛ in. The areas of the heating surfaces are: 1,090 sq. ft. for the tubes; 231 sq. ft. for the superheater elements and 131 sq. ft. for the firebox. The boiler is fitted with a vertical grid-type regulator (comprising a main slide valve and a pilot slide valve), which is placed in the dome and operated by a rod outside the boiler, attached to an arm on a shaft which enters the side of the boiler through a gland. This arrangement can be seen in Figs. 1 and 2; and Fig. 3, opposite, illustrates the fittings on the footplate. It will be seen that there are two regulator handles, one on each side of the cab, connected by a cross-shaft, and opened and closed by a fore-and-aft movement.

The same blocks which were made for forming the flanged plates of the 2-6-4 tank-engine boiler are used for pressing the plates for the 2-6-0 boiler, but the firebox wrapper plates and the barrel plates are slightly shorter. The boiler is provided with the usual standard fittings: top-feed, blow-down valve, self-emptying ashpan, rocking grate, and two Davies and Metcalfe vertical live-steam injectors; but a sand gun for tube cleaning is not fitted. The injectors are both on the right-hand side of the engine, below the footplate, because it has been found that when, as hitherto, the injectors have been placed one each side, the fireman has invariably used the one on his side of the footplate, with the result that the injector on the driver's side has not been maintained in working condition by occasional operation, and has consequently been useless when required in an emergency. The arrangement of the footplate includes several other features which are improvements on the former L.M.S. standard practice. The steam collector for supplying steam to the boiler fittings has been moved from a position inside the cab, on top of the firebox, to a position outside the cab, immediately behind the safety-valves. In this position, the unions, etc., are more conveniently tightened, the cab does not become

2-6-0 FREIGHT LOCOMOTIVE; L.M.R.

MR. H. G. IVATT, M.I.MECH.E., CHIEF MECHANICAL ENGINEER.

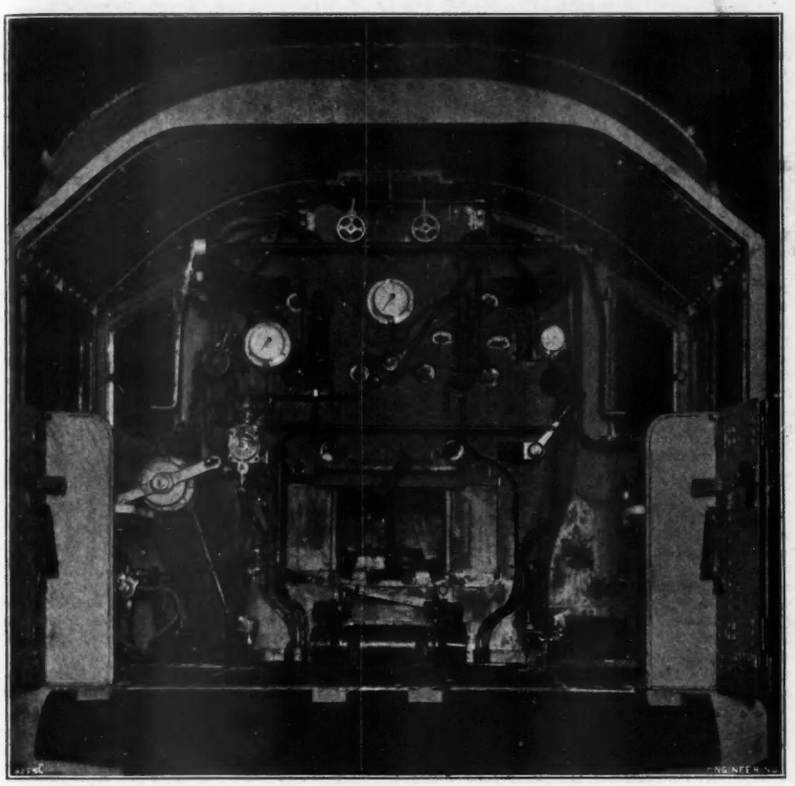


FIG. 3. INTERIOR OF CAB.

so hot in the summer, and any slight steam leaks around the collector do not steam up the windows. The brake and whistle are both provided with duplicate handles, like the regulator, to enable the driver to work on either side of the footplate. The reversing-screw cut-off indicator is in a sloping position to permit more comfortable observation by the driver in a seated position.

The two outside cylinders are 17½ in. in diameter, with a stroke of 26 in., and are steel castings, instead of the usual iron castings. They were made at Crewe Works, and are fitted with renewable cast-iron liners. It is hoped that, except for accidents, the steel cylinders will last for many years, with occasional renewal of the liners. The casing on top of the cylinder houses an air-relief valve. The cylinders exhaust through a double chimney, and blast-pipe which is shown in Fig. 4, on this page. It will be observed that the centre-lines of the orifices form a V; similarly, the centre-lines of the double chimney are at an angle to the vertical, the front chimney sloping forward, and the back one sloping backward. This has been designed to ensure a smooth passage for the exhaust. In most designs of double chimney, the centre-lines of the blast-pipe orifices are parallel, and to achieve this it is necessary to introduce at least one sharp bend in the exhaust passages. The smokebox is provided with the standard self-cleaning fittings. The piston-valves are 10 in. in diameter, the Walschaerts valve-gear has a maximum cut-off of 75 per cent., and the valve lap is 1¼ in.

The frames are fitted with cast-steel one-piece horns, riveted at the sides, but not at the top. The horns have manganese-steel liners, and the frames are braced by pin-jointed cross-stays, and stays across the horn gaps attached to extensions of the frame plates. The axleboxes are lubricated by means of underkeep pads, fed with oil from a mechanical lubricator. The brakes, acting on the coupled wheels, are provided with double blocks to each hanger. A Bissell truck, similar to that designed for the Class 2 tender and tank locomotives, is fitted to the 2-6-0 locomotive. This truck was described and illustrated in ENGINEERING, vol. 163, page 128 (1947). The height of the platform on each side of the locomotive, the double chimney, the shape of the cab, and the modification of certain fittings, impart an unconventional appearance to the locomotive. These changes are the result of an endeavour to simplify the maintenance of the engine, and thereby improve its availability. By setting the platforms higher than usual, on brackets attached to the boiler, they are at a height which is convenient for the fitting staff to work on the cocks, joints, etc., on top of the boiler, without recourse to ladders. Furthermore, the motion, cylinders, piston-valves, and the central sandbox (which stretches across the frames, underneath the boiler), are more accessible. The tender is slightly larger than, but otherwise generally similar to, that designed for the Class 2 2-6-0 engines. Its shape is convenient for the driver to observe the line when running tender first, and it is provided with a cab back-plate and roof for protection from the weather. The capacity of the tender is 3,500 gallons of water and 4 tons of coal. Water pick-up gear, and a filter unit for the injector feed, mounted outside the left-hand frame, are fitted. The fire-irons are stored in a tunnel which is fixed to the platform in front of the cab on the fireman's (right-hand) side.

The tractive effort of the locomotive is 24,172 lb. at 85 per cent. of the boiler pressure. The factor of adhesion is 4·6; the brake ratio for the engine and tender is 60·2 per cent.; and the minimum radius of curve which can be negotiated is 5 chains. The total weight of the engine and tender in working order is 99 tons 8 cwt.; the separate weights are shown in Fig. 2.

CONFERENCE ON LIQUID FUELS.—The Institute of Petroleum and the Institute of Fuel are to hold a joint conference on "Modern Applications of Liquid Fuels" at the University of Birmingham from September 21 to 23. The general scope of the conference will be indicated in an opening address on "The Place of Liquid Fuel in the British Economy." Separate sessions, each of 2½ hours' duration, will then be devoted to such subjects as "Diesel Engines for Power Generation and Railway Traction," "Oil for Gas Making," "Gas Turbines for Land and Marine Power Purposes," "Agricultural Drying Processes," and "Fuel Oil in the Steel, Metal and Glass and Ceramic Industries." Fifteen papers will be presented and these will be printed and issued, bound in one volume, one month before the conference. Further information regarding the conference may be obtained from the secretary, the Institute of Fuel, 18, Devonshire-street, London, W.1.

FIG. 4. DOUBLE BLAST-PIPE.

LAUNCHES AND TRIAL TRIPS.

M.S. "IMPERIAL STAR."—Twin-screw refrigerated cargo liner, with accommodation for twelve passengers, built and engined by Messrs. Harland and Wolff, Limited, Govan, Glasgow, for the Blue Star Line, Limited, West Smithfield, London, E.C.1. Main dimensions: 540 ft. by 70 ft. by 43 ft. 4½ in. to shelter deck; gross tonnage, about 13,500; loaded draught, 30 ft. 6 in. Two Harland-B. and W. eight-cylinder two-cycle double-acting Diesel engines. Trial trip, March 4 and 5.

M.S. "LIPARUS."—Single-screw tanker built and engined by Messrs. Harland and Wolff, Limited, Govan, Glasgow, for the Anglo-Saxon Petroleum Company, Limited, Great St. Helen's, London, E.C.3. Main dimensions: 425 ft. by 54 ft. 3 in. by 31 ft. to upper deck; deadweight capacity, about 9,000 tons on a draught of 25 ft. 6 in. Harland-B. and W. six-cylinder four-cycle Diesel engine. Launch, March 11.

M.SS. "BRADING" and "SOUTHSEA."—Twin-screw vessels with accommodation for 1,400 passengers, together with milk, perishable goods, mails and general cargo, built by Messrs. William Denny and Brothers, Limited, Leven Shipyard, Dumbarton, for the Portsmouth-Ryde ferry service of British Railways, Southern Region. Main dimensions: 200 ft. by 47 ft. 8 in. by 10 ft. 6 in. to main deck. Both vessels fitted with two Diesel engines of Sulzer design and manufacture, giving a speed of 14½ knots. Launch (both vessels), March 11.

S.S. "MATADIAN."—Single-screw vessel for the carriage of palm oil and general cargo, built by Sir James Laing and Sons, Limited, Deptford Yard, Sunderland, to the order of the United Africa Company, Limited, Unilever House, Blackfriars, London, E.C.4. Main dimensions: 410 ft. by 56 ft. 6 in. by 29 ft. 3 in. to upper deck; deadweight capacity, 9,210 tons on a draught of 26 ft. 2 in. Triple-expansion engine of reheat design having an indicated horse-power of 2,200, supplied by The North Eastern Marine Engineering Company (1938), Limited, Sunderland. Service speed, 11½ knots. Trial trip, March 15.

M.S. "MORELIA."—Single-screw cargo vessel, with accommodation for passengers, built by the Aktieselskabet Nakskov Skibsverft, Nakskov, Denmark, for the East Asiatic Company, Copenhagen. Main dimensions: 474 ft. 6 in. by 61 ft. by 29 ft. 9 in. to main deck; carrying capacity, about 10,200 tons. Burmeister and Wain six-cylinder two-cycle double-acting Diesel engine of 5,500 brake horse-power, giving a speed of 15 knots, when loaded. Trial trip, March 31.

METROPOLITAN-LINE SIGNALLING.—A new signalling installation will be opened on a section of the London Transport Metropolitan Line on Saturday, April 17. A master signal cabin in a tower above Harrow-on-the-Hill station will control three automatic signalling frames to the north and south of, and in, the station. The installation is part of a large scheme to improve the flow of traffic in that area on London Transport and Eastern Region lines.

THE IRON AND STEEL INSTITUTE.

The annual general meeting of the Iron and Steel Institute will be held on Wednesday and Thursday, May 5 and 6, at the Royal Institution of Chartered Surveyors, 12, Great George-street, London, S.W.1.

The first session opens at 9.45 a.m. on May 5, when, at the conclusion of the official business, the Bessemer Gold Medal, the second Sir Robert Hadfield Medal, and the Williams Prize, for 1947, will be presented. The President elect, Sir Andrew McCance, D.Sc., F.R.S., will then be inducted and will deliver his presidential address. After this, three papers will be presented in turn and jointly discussed. They are "Construction and Repair of Open-Hearth Furnaces," by Mr. D. C. Muir; "The Design of Open-Hearth Gas Ports," by Mr. M. P. Newby; and "Installation and Use of Instruments on Open-Hearth Furnaces," by Mr. R. C. Baker. The meeting will be adjourned at 1.15 p.m.

The second session will commence at 2.30 p.m., on May 5, when there will be a joint discussion on two papers, namely, "The Production of Nodular Graphite Structures in Cast Irons," by Mr. H. Morrogh and Mr. W. J. Williams, and "The Carbides in Iron-Carbon-Silicon Alloys and Cast Irons," by Mr. D. Marles. From 3.45 until 5 p.m., when the meeting will be adjourned, there will be a joint discussion on two papers by Mr. J. Glen. The first is entitled "Abnormal Creep in Carbon Steels," and the second, "The Creep Properties of Molybdenum, Chromium-Molybdenum, and Molybdenum-Vanadium Steels."

The third Hatfield Memorial Lecture will be delivered on May 5, at 8.30 p.m., by Professor Robert F. Mehl, of the Carnegie Institute of Technology, Pittsburgh, U.S.A. The title will be "The Decomposition of Austenite and Nucleation and Growth Processes."

The last session of the meeting will be held from 9.30 a.m. until noon on Thursday, May 6. The first part of the morning will be devoted to the joint discussion of three papers, namely, "A Micro-Examination of Eight Steels for the Inclusions Sub-Committee," by Dr. J. H. Whiteley; "The Study of Segregations and Inclusions in Steel by Micro-Radiography," by Dr. W. Betteridge and Mr. R. S. Sharpe; and "Some Thermodynamical Aspects of the Formation of Inclusions in Mild-Steel Weld Metal," by Dr. E. C. Rollason and Mr. E. Bishop. During the second portion of the morning, from 10.45 a.m. until noon, there will be a joint discussion on three papers, the first entitled "A Comparison of Moulds of Standard Composition and of Approximately Ingot-Mould Sub-Committee Composition," by Mr. W. L. Kerlie, the second, "Mould-Weight/Ingot-Weight Ratio and its Relation to Mould Composition," by Mr. N. H. Bacon, and the third "Formation of 'Double-Skin' or 'Curtaining' Effect on Top-Poured Mild-Steel Ingots," by Mr. P. Walker. A luncheon for members will be held at 12.45 for 1.15 p.m., at the Dorchester Hotel, Park-lane, London, W.1.

British Electricity Authority.—The British Electricity Authority held a vesting-day reception at the Savoy Hotel, London, on Thursday, April 1, "as a gesture of friendliness towards the electrical industry on the first day of its assumption of control." The guests, who were received by Lord Citrine, included representatives of the Government, the professional institutions, and industry.

Automatic Lifts on London Underground Railways: Erratum.—In the article on "Automatic Lifts on London Underground Railways," which appeared on page 213, *ante*, it was stated that a slow dropping relay chain was used at the Strand station "to move a master selector relay at a pre-determined rate and thus to transmit the starting impulse to the equipment on each lift." It should also have been stated, however, that although this arrangement formed part of the original installation, it was subsequently replaced by a film drum (described later in the same paragraph) owing to its liability to error.

Variable-Ratio Drive.—A novel design of variable-ratio drive, known as the "Multibelt," is described in a leaflet received from Multibelt (England), 71, High-street, Beckenham, Kent. It consists of two parallel shafts, each with a pulley which can be varied in diameter, connected by several V-belts. Each pulley has the appropriate number of grooves to suit the belts, and a cross section of a pulley would show that it was composed of several segments, which can be moved radially outwards to give the largest diameter (in which position the periphery of each belt groove is not continuous, but is broken at the gaps between the segments), or radially inwards to give the smallest diameter (in which position the periphery of each groove is continuous, and similar to that of a normal pulley). The ends of the segments fit in slideways in two coned members; one cone is fixed on the shaft, and the other slides on splines, which has the effect of altering the size of the pulley. Several sizes are available, with a maximum capacity of 14 h.p.

CONTRACTS.

Messrs. The Brush Electrical Engineering Company, Limited, Loughborough, Leicestershire, have received an order for the bulk of the equipment for the power station of the Chilanga cement factory of the Northern Rhodesian Government. The contract comprises a 1,500 kW, 3·3 kV Brush-Ljungstrom radial-flow double-rotation turbo-alternator set to operate with steam at 230 lb. per square inch, and 725 deg. F. at the turbine stop valve (the altitude of the site being 4,200 ft. above sea level), together with twin John Thompson boilers, a 400-kW stand-by Diesel-driven alternator, switchgear, and other plant. A second order is for a 7,500-kW turbo-alternator of similar type for the West Bank Power Station, East London, of the Electricity Supply Commission of South Africa. This will operate at 200 lb. per square inch, and 750 deg. F. at the turbine stop valve.

The Glasgow Corporation Water Department have placed a contract with Messrs. A. M. Cochran and Company, Glasgow, for the laying of 2,200 lineal yards of 24-in. internal-diameter concrete-lined cast-iron pipes as a branch main from the new 36-in. diameter East Main. Another contract, for the supply of 2,000 yards of 30-in. internal-diameter concrete-lined pipes, has been placed with the Staveley Coal and Iron Company, Limited, near Chesterfield. A third contract, for four 24-in. diameter, vertical, manually-operated sluice valves has been placed with Messrs. Glenfield and Kennedy, Limited, Kilmarnock.

BOOKS RECEIVED.

The British Journal Photographic Almanac, 1948. Edited by Arthur J. Dalladay. Henry Greenwood and Company, Limited, 24, Wellington-street, Strand, London, W.C.2. [Price 5*s*. net (paper board covers), 6*s*. net (cloth bound).]

Electricity Supply: Directory of B.E.A., Boards and Officials. Electrical Review Limited, Dorset House, Stamford-street, London, S.E.1. [Price 2*s*. net.]

Illustrated Jig-Tooling Dictionary. By Torger G. Thompson and Ross A. Peterson. The Macmillan Company, 60-62, Fifth-avenue, New York 11, U.S.A. [Price 7.50 dols.] Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 37*s*. 6*d*. net.]

The Performance and Design of Alternating Current Machines. By Professor M. G. Say. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 25*s*. net.]

The Electric Wiring of Buildings. By F. Charles Raphael. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 20*s*. net.]

Uses of Traffic Accident Records. A Manual Prepared by a Committee of the National Conference on Uniform Traffic Accident Statistics. Eno Foundation for Highway Traffic Control, Incorporated, Saugatuck, Connecticut, U.S.A. [Free.]

The Law in Relation to Partners. By Peter Elman. Stevens and Sons, Limited, 119 and 120, Chancery-lane, London, W.C.2. [Price 4*s*. net.]

A Practical Evaluation of Railroad Motive Power. By P. W. Kiefer. Simmons-Boardman Publishing Company, 30, Church-street, New York, U.S.A. [Price 2 dols.]

Reference Books for the Works Library. By R. Brightman. Aslib Pamphlet No. 2. Association of Special Libraries and Information Bureaux, 52, Bloomsbury-street, London, W.C.1. [Price 2*s*.]

Our Rivers. By J. W. Kempster. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 25*s*. net.]

United States Bureau of Mines. Miners' Circular No. 59. *Electrical Accidents in Bituminous-Coal Mines. Coal-Mine Accident-Prevention Course.* Section 6. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 30 cents.]

The Science and Engineering of Nuclear Power. Edited by Clark Goodman. Addison-Wesley Press Incorporated, Kendall Square Building, Cambridge 42, Mass., U.S.A. [Price 7.50 dols.]

United States National Bureau of Standards. Circular No. 463. *Safety for the Household.* Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 75 cents.]

The Cathode Ray Oscillograph in Industry. By Dr. W. Wilson. Third edition, revised. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 18*s*. net.]

Coal Mining in Australia. By Harold S. Elford and Maurice R. McKeown. Tait Publishing Company Pty. Limited, 349, Collins-street, Melbourne, C.1. [Price 15*s*.]

Bücher der Technik. Grundgesetze der Regelung. By Dr.-Ing. Winfried Oppelt. Wolfenbütteler Verlagsanstalt G.m.b.H., Wolfenbüttel-Hannover, Germany.

PERSONAL.

Lt.-Col. Lord Dudley Gordon, D.S.O., has been elected President of the British Refrigeration Association 1, Lincoln's Inn Fields, London, W.C.2. Sir Samuel R. Beale, K.B.E., Mr. K. Lightfoot, O.B.E., and Mr. A. M. Allan have been elected vice-presidents.

Dr. Oscar Faber announces that he has taken into partnership Mr. S. Vaughan, B.Sc., M.I.C.E., M.I.Struct.E., A.C.G.I.; Mr. K. Montgomery-Smith, B.Sc., M.I.C.E., M.I.Struct.E.; Mr. J. R. Kell, A.M.I.Mech.E., M.I.H.V.E.; Mr. C. R. Glover, B.Sc., M.I.C.E., M.I.Struct.E.; and Mr. J. G. Faber, B.Sc., A.M.I.C.E., A.M.I.Struct.E., A.C.G.I. The firm will now be known as Oscar Faber and Partners, and will continue to operate from 1, Worley-road, St. Albans, and 4, Verulam Buildings, Gray's Inn, London, W.C.1.

The British Electricity Authority have appointed Mr. W. B. Noddings, M.Eng., M.I.E.E., and Mr. R. Y. Sanders, F.S.S., to be deputy commercial managers; Mr. V. A. H. Clements, M.I.E.E., Mr. C. M. Johnston, B.Sc., A.M.I.E.E., Mr. F. S. Naylor, B.Sc., A.C.G.I., M.I.E.E., and Mr. R. H. S. Piercy, A.C.G.I., A.M.I.E.E., to be assistant commercial managers; and Mr. J. A. Lee, M.I.E.E., M.I.Mech.E., to be transmission construction engineer, head office.

Mr. W. J. Boddy, manager of the electrical construction department, the British Thomson-Houston Company, Limited, since 1918, retired on April 1, after 51 years' service with the company. Mr. A. S. Kettle, M.I.E.E., has been appointed manager of the construction department as from April 1.

Mr. E. C. Poultney, O.B.E., M.I.Loco.E., has been elected a director of Locomotive Valve Gears, Limited, 47, Victoria-street, London, S.W.1.

Lord Provost Powrie, of Dundee, and Mr. J. M. Erskine, general manager, Commercial Bank of Scotland, have been appointed additional members of the North of Scotland Hydro-Electric Board.

Mr. Harry Towers, director and general manager, Messrs. A. Reyrolle and Company, Limited, Hebburn, County Durham, has been appointed managing director of the company.

Mr. Keith Fraser, M.A., A.M.I.C.E., M.I.Chem.E., has been elected to the board of directors of Messrs. Dewrance and Company, Limited.

Mr. S. W. Marsh, until recently a senior technical assistant in the design office of the Birmingham Railway Carriage and Wagon Company, Limited, has been appointed chief engineer to the Andre Rubber Company, Limited, Kingston By-Pass, Surbiton, Surrey.

Mr. A. S. Johnston, A.R.Ae.S., has been appointed aviation sales manager of the aircraft instrument factory of Messrs. Kelvin, Bottomley and Baird, Limited, Winchester-road, Basingstoke.

Mr. A. Milne, M.I.Mar.E., has been appointed engineer manager of Messrs. Swan, Hunter, and Wigham Richardson, Limited, Dry Docks, Wallsend-on-Tyne.

Mr. H. Leak, C.B.E., Director of Statistics, Board of Trade, retired on March 31 and became statistical adviser to the Board on a part-time basis. He has been succeeded as Director of Statistics by Mr. J. Stafford, of the Central Statistical Office.

Mr. W. C. Bolton, London district road-motor engineer, British Railways, Western Region, retired on April 5. He joined the staff of the Great Western Railway Company in 1904.

Mr. J. Cunningham, district engineer Abergavenny, London Midland Region, British Railways, has been appointed district engineer, Bangor. Mr. H. L. Douglas, assistant to the district engineer, Glasgow (Scottish Region), is succeeding Mr. Cunningham as district engineer, Abergavenny.

Colonel D. R. Johnson has been appointed sales executive of Messrs. Bryce Fuel Injection Limited, Ironbarks Works, Staines, Middlesex.

Mr. H. Cunningham, formerly commercial manager of Redheugh Iron and Steel Company, Limited, has been appointed general manager of Messrs. A. J. Riley and Son, Limited, boilermakers, Batley.

Messrs. Thos. W. Ward, Limited, Albion Works, Sheffield, have purchased, as a going concern, the Imperial Works, Coverack-road, Newport, Mon., of Messrs. D. G. Hall and Company, Limited. Messrs. Ward intend to develop to the full the scope of the various workshops.

Messrs. Oerlikon (Reconstructed) Limited, electrical engineers and contractors, Victoria House, Southampton-row, London, W.C.1, announce that, in future, the name of the company will be: Oerlikon Limited. In all other respects the firm remains unaltered.

The Stainless Steel Fabricators' Association, formed in London in November, 1946, have now changed their name to Stainless Steel Fabricators' Association of Great Britain. The Association's office remains at the Chamber of Commerce, 95, New-street, Birmingham, 2.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—A satisfactory rate of production is being maintained at the local steelworks. In the period from March 1 until the stoppage for Easter, outputs were understood to be at a rate of over 2,000,000 tons per annum, which figure is generally taken as Scotland's target for 1948. The industry is ready to maintain the present outputs, but makers are considerably perturbed over the question of scrap supplies. Re-rollers resumed after the holiday with somewhat lighter order books following the cancellation of orders which had not been re-authorised, but substantial bookings are still held. A fairly reasonable supply of semies has been forthcoming, but there is still a scarcity of billets under 3-in. square. The sheet-bar position has improved slightly, although supplies are still being drawn solely from local sources. Tubemaking is one of the busiest branches of the trade at the moment in Scotland, and high tonnages are being shipped to the Middle East and other oil-producing countries. Scottish steelmakers are expecting an increase in steel exports in Period 2, as indicated by allocations already specified and the large commitments under the several trade agreements negotiated by the United Kingdom in recent months.

Scottish Coal.—Production in the Division is still failing to reach the weekly target of 500,000 tons, outputs in the week ended March 27 totalling some 475,000 tons. To stimulate production, the Scottish Area of the N.U.M. have submitted to the national executive a request for an incentive bonus for all miners, based on output. Unofficial stoppages have been reducing weekly tonnages for a long time now, but an agreement has been signed between the N.C.B. and the N.U.M., which, it is hoped, will eliminate many of them. The agreement came into force on Monday last, and stipulates that seven days' written notice must be given before miners' employment is terminated by miner or employer. The combined production of the deep mines and open cast sites has been sufficient to meet the needs of inland consumers. Gasworks and electric-power stations are holding good stocks, while deliveries are at the allocation level. Deliveries to steelworks and coke-ovens have been satisfactory for the present rate of throughputs, while general industrial supplies have been maintained in accordance with programme figures. Available supplies of round coal continue to improve slightly, and allocated tonnages have been moving to railways and domestic users, although the demand for house coal is slackening. Surplus fuel for export is below expectations, but a steady trade is passing to Sweden, Finland, Denmark, and occasionally France. Shipments to Eire are regularly being stemmed at Ayr at the improved rate of about 2,500 tons weekly.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—An investigation into the administration of the nationalised coal industry in South Wales has been undertaken by the South Wales miners' executive council. It followed complaints from miners' lodges about administrative difficulties, particularly in regard to labour relations. Several reports have been received from the lodges and these have been tabulated. The Easter-holiday interruption in productions has continued to affect the coal market during the past week. Owing to the slowing down, delays have been caused in some deliveries and operators have been hard pressed to keep pace with their programmes, without adding to their commitments for the moment. As a result of this, the amount of foreign business concluded for delivery during April has been limited. During the past week, orders have been arranged for three shipments to Buenos Aires, one of 3,000 tons to West Italy, one to Lisbon, as well as the usual quotas for France and Eire. Canadian business has been proceeding along steady lines. Although there has been this delay, shippers do not anticipate that the amount of coal shipped in April will show any reduction from the level of the past few months. Some increase in the amount of coal that can be spared for delivery abroad is looked for in the not far distant future as the usual seasonal influences reduce home consumption. The requirements of the essential home industries are still sufficiently heavy to account for almost the whole of potential outputs, especially of the better sorts, for some time to come. Cokes and patent fuel continue to receive attention and supplies for early delivery are limited.

THE INSTITUTE OF WORKS MANAGEMENT.—The members of the Institution of Factory Managers and of the Institution of Works Managers have decided, at recent general meetings of their respective institutions, to amalgamate as from July 1, 1948, under the new title of the Institute of Works Management. The office of the new Institute has been established already at 67-68, Chandos-place, London, W.C.2. (Telephone: TEMple Bar 8324.)

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Production is in full swing again following the holidays; there was a satisfactory return to work. Very little repair and maintenance work could be carried out during the break because maintenance engineers refused to work during the holiday period as their 18 months-old claim for a 20 per cent. increase in overtime rates had not been conceded. It is expected that the accumulation of repair jobs may lead to breakdowns later on. Fortunately, bricklayers are not included in the dispute and furnace re-lining was not interfered with. Maintenance work was carried out at the works of the United Steel Companies, however, as their maintenance engineers are not concerned in the dispute.

South Yorkshire Coal Trade.—The effects of the holidays at the pits is now wearing off. Complaints are not so frequent regarding the quantity of coal being allocated as about the quality, since the formulation of the National Coal Board policy to export the best qualities at the expense of the home user. Some of the outcrop coal distributed is of very inferior quality. More coking coal is being sought to permit the full operation of coking plants, which are experiencing a heavy demand for coke.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The demand for larger deliveries of iron and steel continues and efforts to increase the present heavy outputs are being made. Following the cancellations of uncompleted orders at the end of March, tonnage allocations of steel over the second quarter of the year are issued for specific purposes, with supplies directed to destinations where they are likely to be of the greatest benefit to national needs. Inadequate supplies of cast-iron scrap, foundry pig and steel semies are still hampering operations at plants turning out commodities for home purposes and for shipment overseas. Tees-side pig-iron makers are wholly engaged in dealing with the steel-producers' requirements and are unable to cater for the appreciable demands for iron made by the foundry industry.

Foundry and Basic Iron.—There seems to be no likelihood of a resumption of the make of Cleveland foundry pig and the intermittent output of a substitute quality of iron has shrunk almost to vanishing point. North-East Coast founders are thus more than ever dependent on regular supplies of pig from producing areas at a distance. Basic-iron output is conveyed directly from the blast-furnaces to the makers' own consuming departments in quantities that cover essential needs but larger deliveries would be much appreciated by the melting departments concerned.

Hematite, Low-Phosphorus and Refined Iron.—East-Coast hematite consumers are receiving parcels on a scale that suffices for present requirements, but are pressing for larger deliveries to enable them to replenish their stocks. The outputs of low- and medium-phosphorus grades of iron are steadily absorbed and makers of refined-iron report that there is a regular demand for their products.

Manufactured Iron and Steel.—Foundry and steelworks scrap is coming forward in slightly better quantities from the Continent but there is an insistent demand for much larger parcels. Finished and semi-finished iron outputs are not sufficient for customers' urgent requirements, and the delivery obligations of steel producers continue on an embarrassing scale though the extent of the tonnage on order was reduced substantially by the cancellation of uncompleted contracts at the end of March. The intense demand for larger parcels of semi-finished steel continues. Billets, blooms, slabs and sheet bars especially are wanted in large quantities. Some little improvement in imports is reported and slightly better deliveries from home sources are anticipated Buyers of the various descriptions of finished steel are anxious to place new orders. Manufacturers of sheets, railway requisites, shipbuilding material, and colliery equipment continue to experience an exceptionally heavy demand.

ACQUISITION OF PRIVATELY-OWNED WAGONS.—Over 370,000 privately-owned railway wagons have been purchased by the British Transport Commission in accordance with sections 29 to 32 of the Transport Act, 1947. The amount to be paid in compensation for different types of wagons, according to their ages, was stipulated in the sixth schedule to the Act. The total cost to the Commission is approximately 45,000,000*l.*, of which 13,500,000*l.* is reserved for National Coal Board wagons. Most of the payment to former private owners of the wagons has been made by an issue of British Transport Stock.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Western Centre:* Monday, April 12, 5 p.m., Institute of Engineers, Park-place, Cardiff. "Neutral Earthing of Three-Phase Systems," by Messrs. J. R. Mortlock and C. M. Dobson. *Southern Centre:* Monday, April 12, 6.30 p.m., Technical College, Brighton. "Electric Traction on the Southern Railway," by Mr. C. M. Cock. *Radio Section:* Tuesday, April 13, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Design of Receiving Aerials," opened by Mr. E. M. Lee. *Transmission Section:* Wednesday, April 14, 5.30 p.m., Victoria-embankment, W.C.2. "Transmission of Electrical Energy Over Long Distances," by Dr. W. Wanger. *Scottish Centre:* Wednesday, April 14, 6 p.m., Heriot-Watt College, Edinburgh. "The Cavity Magnetron," by Drs. H. A. H. Boot and J. T. Randall, F.R.S. *Installations Section:* Thursday, April 15, 5.30 p.m., Victoria-embankment, W.C.2. "The Flash Tube," by Dr. J. N. Aldington and Mr. A. J. Meadowcroft. *Measurements Section:* Friday, April 16, 5.30 p.m., Victoria-embankment, W.C.2. "Electrical Measurement of Pressure and Strain," by Mr. R. W. Wild.

INSTITUTION OF PRODUCTION ENGINEERS.—*Halifax Section:* Monday, April 12, 7 p.m., White Swan Hotel, Halifax. "Inspection and Production," by Mr. B. McMahon. *Sheffield Section:* Wednesday, April 14, 6.30 p.m., Royal Victoria Hotel, Sheffield. "Deep Drawing in Electro-Plate Industry," by Mr. F. Parkinson. *Glasgow Section:* Thursday, April 15, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Machine Tool Users' Difficulties," by Mr. R. Taylor.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Sheffield Branch:* Monday, April 12, 7.30 p.m., Royal Victoria Hotel, Sheffield. Annual Meeting. "Choice of Metals for Use as Castings," by Mr. E. Wilson.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 13, 5.30 p.m., Great George-street, S.W.1. "Shuttering," by Mr. C. Parry.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, April 13, 5.30 p.m., 85, Minories, E.C.3. "Radiography of Welds," by Mr. R. F. Bishop.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, April 13, 6.15 p.m., Royal Victoria Hotel, Sheffield. "Thin Films on Metals," by Dr. Ulick R. Evans.

WOMEN'S ENGINEERING SOCIETY.—*London Branch:* Tuesday, April 13, 7 p.m., 35, Grosvenor-place, S.W.1. "Structural Engineering," by Miss L. Chitty.

ROYAL SOCIETY OF ARTS.—Wednesday, April 14, 2.30 p.m., John Adam-street, W.C.2. "District Heating," by Mr. Henry S. Horsman.

INSTITUTION OF WATER ENGINEERS.—*South Eastern Section:* Wednesday, April 14, 2.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Legislation Affecting the Engineer," by Mr. L. W. F. Millis.

NEWCOMEN SOCIETY.—Wednesday, April 14, 5.30 p.m., Science Museum, S.W.7. "Warehouse Hoists," by Mr. T. M. Hoskison. "Brake Wheels and Wallowers," by the late H. O. Clark and Mr. Rex Wailes.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, April 14, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, S.W.1. Annual Meeting. "Notes on Railway Standards," by Mr. T. T. Lambe.

INSTITUTION OF MINING AND METALLURGY.—Thursday, April 15, 5 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Detection, Separation and Micro-Titration of Iridium," by Dr. W. B. Pollard. "A New Form of Thermal Precipitator," by Mr. P. H. Kitto.

ROYAL AERONAUTICAL SOCIETY.—Thursday, April 15, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Aerodynamic Problems of High-Altitude Design," by Mr. W. E. W. Petter.

INSTITUTION OF CHEMICAL ENGINEERS.—Friday, April 16, Connaught Rooms, Great Queen-street, W.C.2. 11.45 a.m., Business Session. 2.30 p.m., Presidential Address on "The Chemical Engineer and Civilisation," by Mr. H. W. Cremer.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 16, 5.30 p.m., Storey's-gate, S.W.1. Discussion on "Mobile Locomotive Testing Plant of the L.M.S.R.," by Dr. H. I. Andrews.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 16, 6.30 p.m., 39, Victoria-street, S.W.1. "Manufacture of Gramophone Records," by Mr. H. W. Bowen.

ROYAL INSTITUTION.—Friday, April 16, 9 p.m., 21, Albemarle-street, W.1. "The Gas Industry," by Dr. E. V. Evans.

FLEXIBLE CONCRETE MATTRESSES FOR BANK PROTECTION; RIVER MISSISSIPPI.

(*For Description, see Page* 337.)

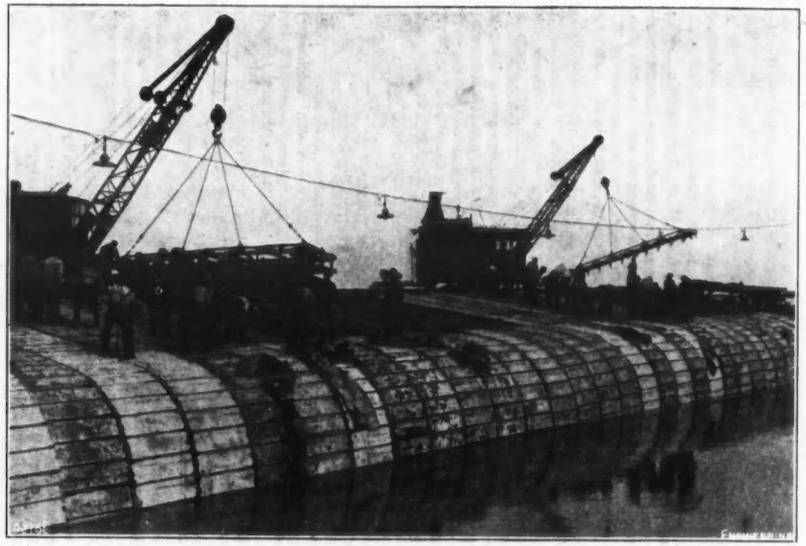


FIG. 5. LAYING CONCRETE-BLOCK MATTRESSES.

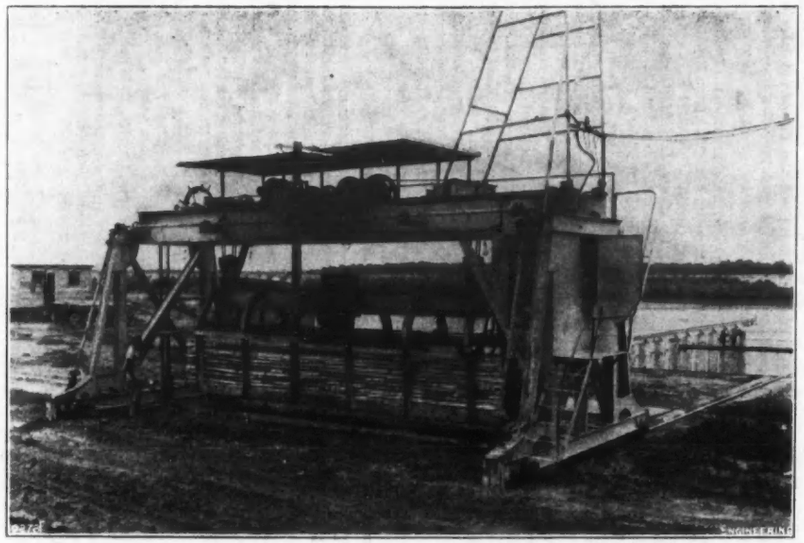


FIG. 6. ELECTRIC HOIST FOR LOADING MATTRESSES ON TO BARGES.

FIG. 7. SINKING-BARGE FOR ASSEMBLING AND LAUNCHING MATTRESSES.

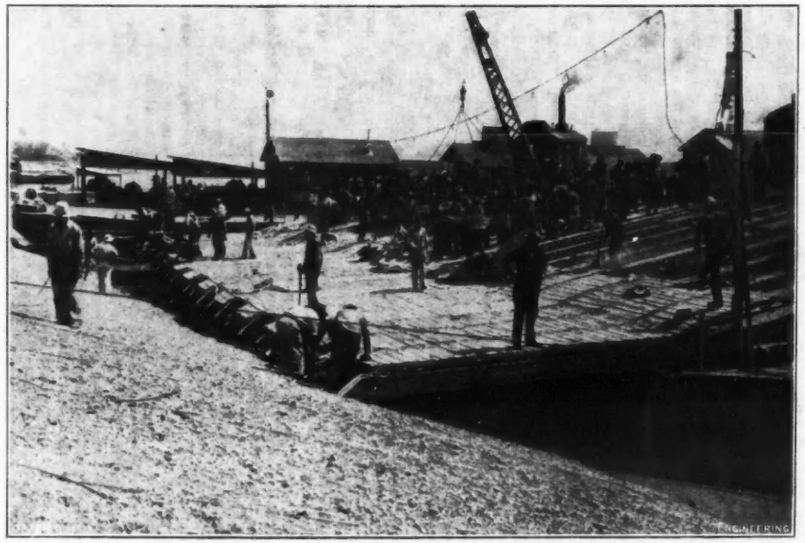


FIG. 8. LAYING LAND END OF MATTRESS.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

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Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

INDEX TO VOL. 164.

The Index to Vol. 164 of ENGINEERING (July-December, 1947) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, APRIL 9, 1948.

VOL. 165. No. 4289.

THE MERCHANT FLEETS OF THE WORLD.

FOR those who are interested to follow the fortunes of the British mercantile marine, and its position and prospects in relation to the merchant fleets of other maritime nations, there have been for many years few works of reference of greater value and appeal than the portly volume known prosaically as the *Appendix to Lloyd's Register Book*. Naturally, it could not be published during the war, and, so extensive have been the changes resulting from the war that only now, nearly three years after the termination of hostilities, has publication been resumed. The volume for 1947-48, which was published on March 31, is even now incomplete in certain respects, as no reliable information about Japanese shipping losses was received until after the *Register Book* for this year was printed. It appears that more than 4,000,000 tons of Japanese ships were lost; so, as the compilers observe with notable understatement, "the statistics for that country require to be largely discounted." Moreover, many changes of ownership and management took place in the war years and the re-allocation of the vessels concerned is not yet complete. The hope is expressed that more precise particulars may be embodied in the 1948-49 *Register Book*.

The comparison of world tonnage in existence at June, 1939, and June, 1947—the figures, like all others here quoted, being gross tons—shows that a total of 69,439,659 tons in 1939 had grown to 84,356,257 tons in 1947, in spite of the enormous losses sustained by the belligerents and many neutrals. Of these totals, the proportion owned in Great Britain and Northern Ireland has remained almost exactly uniform—17,984,158 tons in 1939 and 17,948,839 tons in 1947; relatively, therefore, the British mercantile marine has declined appreciably, though the fact that more new construction is in hand in British yards than anywhere else in the world (and most of it for British owners) should go some way to restore the pre-war position. The leeway to be made up, however, is more than appears at first sight, as the 1947 total of tonnage for Britain and Northern Ireland includes nearly 1¾ million tons on charter from the United States and Canada.

Since the British totals show such a small variation from 1939 to 1947, while the world total rose from 69 millions to 84 millions, it follows that the increases under some other flags must be relatively enormous. Easily first in its expansion, of course, is the merchant fleet of the United States, which has increased by 20,887,717 tons. No other single country can show anything even remotely comparable with this increase; but some of the smaller fleets have developed in a manner which would have excited much remark if they had not been so overshadowed. Nearly a million tons (989,333) have been added to the flag of Panama; Russia has gained 848,701 tons—though, "owing to the difficulty experienced in obtaining precise information in the case of Soviet Russia, the figures given for that country may not be comprehensive"; Canada can claim an additional 650,728 tons; and even Honduras has shared in the expansion to the tune of nearly 194,000 tons. Many countries, however, show considerable decreases, apart from Germany, which has lost 86·8 per cent. of the pre-war total of tonnage, and Italy, which records a fall of 62·0 per cent. Denmark (— 12·8 per cent.), France (— 21·1 per cent.), Greece (— 42·3 per cent.), Holland (— 18·0 per cent.) and Norway (— 22·2 per cent.) have all paid a heavy price for their part in the maritime operations of the war. Quantitatively, however, only four countries show falls of more than a million tons, these being Germany, which lost 3,894,456 tons, Italy (2,131,298 tons), Norway (1,073,131 tons), and, of course, Japan

The figures of total tonnage, quoted above, relate to all vessels of 100 tons gross or more, irrespective of age; many of them, therefore, can hardly be regarded as suitable for general seagoing service. Another table in the *Appendix*, however, applies the necessary corrections by re-stating the relative tonnages owned by the principal maritime nations which are "available for general cargo and passenger purposes." This table omits all ships trading on the Great Lakes of North America, all wooden and composite vessels, all of less than 4,000 tons gross, and all of 25 years of age or upwards (except a few, built before 1922, which are still capable of high speed); together with a number of special types such as tankers, trawlers, tugs, ferries, dredgers, cable ships, and vessels owned by municipal and harbour authorities. When these exceptions are made, it is found that the remaining world tonnage of ocean-going steamers and motorships consists of 5,657 vessels aggregating 41,337,672 tons. Of this total, the United States possesses 48·59 per cent. and Britain and Northern Ireland, 25·18 per cent. No other single nation approaches anywhere near these percentages, the nearest being Holland, with 3·16 per cent., France, with 2·93 per cent., Norway, with 2·61 per cent., and Canada, with 2·06 per cent. The rest are well below 2·0 per cent. each.

As the compilers of the statistics comment, these figures demonstrate the relatively high efficiency of the merchant fleets of the United States and of Great Britain, in spite of the large deductions made in respect of tanker tonnage and of the Great Lakes fleets. There are in the *Register Book* 2,079 seagoing oil tankers, totalling 15,717,923 tons, of which 864, of 7,539,825 tons, are registered in the United States. Those of British registry number 434, of 3,025,658 tons; and Norway has 194, of 1,648,667 tons. In addition, there are rather more than 239,000 tons of tankers of less than 1,000 tons each. The tonnage of steam and motor trawlers, other fishing vessels, and whalers amounts to a little over a million; and other smaller categories, in round figures, include some 582,000 tons of tugs and salvage vessels, 265,000 tons of ferries, 76,000 tons of cable ships, and 504,000 tons of river craft, dredgers, self-propelled barges, etc. The total of all these various classes of vessels not used for ordinary passenger and cargo purposes, irrespective of size, age or material of construction, amounts to about 18,440,000 tons. The tonnage of sailing vessels, non-propelled barges, etc., which was 3,963,000 at June, 1914, and had fallen to 930,000 tons at June, 1939, now stands at about 842,000—less than 1·0 per cent. of the world's tonnage. More

than half of these 842,000 tons is under the United States flag and 101,000 tons are British-owned.

The tendency towards increased average size of seagoing vessels continues. In 1914, there were 3,608 such ships, steam and motor, of 4,000 tons or more each; now there are 8,669, of which total 969 are of 10,000 tons or above, 49 of these being of 20,000 tons or more. Of the 969 mentioned, 198 are under the British flag. It is to be expected that the immensely increased shipbuilding output of the war years should have the effect of reducing the average age of merchant fleets, and the higher speeds now usual probably played some part also, during the war, in perpetuating the old distinction between the "quick" and the "dead." According to the *Appendix*, there are 6,651 steamers and motorships which are less than five years old, their tonnage representing 43·9 per cent. of the total. Their average tonnage is 5,511, whereas, of the 12,584 vessels of 25 years of age or more, the average tonnage is only 1,588. Of the 1,948 vessels of 8,000 tons or more, now in existence, 964 were built during the past five years. The British mercantile marine lost very heavily during the war, and replacements were necessarily extensive, so that 36·8 per cent. of the British-owned total is now less than five years old. Of the tonnage registered in Great Britain and Northern Ireland, 74·7 is under 20 years old and 65·0 per cent. is under 15 years; corresponding percentages of tonnage owned abroad are 69·5 and 62·9 per cent.

On the machinery side, the 1947-48 *Appendix* presents some interesting comparisons, especially in the supersession of coal by oil; though it does not follow that every steamer fitted to burn oil fuel is always doing so, as many vessels alternate between oil and coal according to circumstances. In 1914, 88·84 per cent. of the world's tonnage burned coal. By 1935, the proportion had fallen to 50·15 per cent. and at June, 1939, to 44·67 per cent. Now, it is 26·2 per cent. Vessels fitted to burn oil fuel in boilers represented only 2·65 per cent. in 1914, but 30·65 per cent. in 1935; thereafter there was a slight decline to 29·63 per cent. in 1939, but the percentage has now risen again to 52·52—attributable in part, no doubt, to the exceptional war-time conditions, in the United States particularly, when oil-fired steam machinery could be constructed more quickly, and by a wider range of builders, than marine internal-combustion engines of large size. The percentage of world tonnage using oil in internal-combustion engines, which was only 0·45 in 1914, had become 17·42 per cent. in 1935 and climbed slowly but steadily to 24·36 per cent. in 1939; now, however, it is only 20·28 per cent.

When numbers of ships are considered, however, rather than relative percentages of the world total, the comparison of steam with internal-combustion machinery takes on a somewhat different aspect. There are now, it is stated, 2,764 steamers, of 20,715,338 tons, fitted either with steam turbines or with a combination of turbines and reciprocating engines, as compared with 1,964, of 12,617,958 tons, in 1939; but vessels fitted with internal-combustion engines, though more numerous now than in 1939 (8,757 as against 7,551), represent only a slight increase in aggregate tonnage, the respective figures being 16,918,687 tons in 1939 and 17,104,959 tons in 1947. The corresponding tonnages of steamers and motorships in 1914 were about 730,000 and 234,000 tons, respectively, showing how much more numerous and important were steam reciprocating engines before the first World War. Of the world's seagoing tanker tonnage, 10,256,981 tons are steam-driven and 5,460,942 tons by internal-combustion engines. The proportion of motorships varies greatly in different countries, in part, no doubt, as a result of the war; whereas motorships represent only 20·3 per cent. of the world total and 29·1 per cent. of British-registered tonnage, the percentage under the Norwegian flag is 66·7, Sweden has 65·7 per cent., and Denmark 56·3 per cent. Greece, the United States and Canada have the least in proportion, their respective motorship percentages being only 1·6, 5·0 and 8·0, respectively. Finally, it may be noted that 641 vessels, aggregating 5,691,888 tons, are electrically propelled; but only 196, totalling no more than 127,609 tons, now use paddles.

THE LONDON PASSENGER TRANSPORT BOARD.

It is fitting that, in its final report, the London Passenger Transport Board should give some account of its years of stewardship. In common with other organisations, 1947 witnessed its extinction in the general re-organisation to which, for better or worse, so many of the activities of the country are now being subjected. The Board has been hardly treated by fate. It may be assumed that the high hopes of benefit to follow the co-ordination of passenger transport in the London area, which were held by those who were responsible for the creation of the Board, were shared by its members, but of the fourteen and a half years over which its activities have been spread, only six have fallen in normal times and these were at the beginning, when much preliminary work, largely of an administrative character, had to be carried out before schemes of any magnitude for the improvement of services and methods could be put in hand. The extent of the initial work of co-ordination which had to be done is well illustrated in connection with road transport. In addition to the comprehensive services operated by the London General Omnibus Company and the Tilling companies, the Board took over 55 independent concerns operating in the central area and 60 running services in the outer country districts.

The fourteenth, and last, report* of the Board, although it has to record much delay and frustration in connection with the New Works Programme which was undertaken in 1935, and should have been completed in 1940, can still point to much which has been achieved. This programme was largely concerned with railway electrification and extensions and covered the provision of through services from the Board's central system to West Ruislip, Bushey Heath, Wood Green and Ongar, and electrification of the Shenfield line of the old London and North Eastern Railway. Work continued in the early part of the war, but was entirely suspended in the spring of 1941. At that time the new tube connection from Baker Street to Finchley Road had been completed and the High Barnet line had been electrified. This latter conversion furnishes a striking illustration of the passenger-attracting power of the frequent service which can be provided economically on an electrified line. Since conversion, traffic has increased nearly threefold. Although even now the full programme is not being worked on, considerable progress was made last year, the extension of the Central Line from North Acton to Greenford being opened on June 30, and, at the eastern end, the extension as far as Woodford going into service on December 14.

It is not only in the field of civil-engineering work that the Board's activities have been hampered by the prevailing shortages. The same thing applies to rail and road vehicles. During the war, the replacement of rolling stock virtually ceased and maintenance services were much reduced. To bring railway stock up to the standard required by the growth in traffic and the extension of the system, 143 new surface-line cars were ordered, with delivery commencing in 1947, but the prospects now are that that event will be postponed until the latter part of this year. At the end of 1947, the Board sought authority to purchase a further 90 new surface cars and 89 new tube cars, as well as permission to modify existing stock to the extent of 86 surface and 44 tube cars. This matter has now passed beyond the Board's control and the report does not give any indication of when this extra material is likely to be obtained, or the conversion work undertaken.

Similar conditions of delay and uncertainty exist in connection with road vehicles. The fleets which were taken over when the Board was formed totalled 5,500 'buses and 500 coaches; these were mainly petrol-engined vehicles and included a large number of the NS double-deck 'buses with outside staircases which had been introduced by the London General Omnibus Company in 1923. The improved STL 'bus was designed and introduced early in the history of the Board and became available at the rate of 500 per annum. An early change to heavy oil in place of petrol was also made, and the oil engine was adopted as the standard power unit, both for 'buses and coaches, in 1934. Post-war conditions reflect the general supply position. Contracts for a total of 4,000 of the latest RT type of 'bus have been placed, but by the end of 1947, only 182 had been delivered. The orders include 500 of the increased width of 8 ft. which has now been sanctioned, but none had been received in 1947. The garage situation also is unsatisfactory.

The demand for a greatly-increased fleet of oil-engined 'buses has been accentuated by the decision to replace the South London trams by vehicles of this type. Initially, the Board took over 327 miles of tram route and 17 miles of trolley-'bus route, and it was decided gradually to convert the tram services to trolley-'bus operation. By 1940, practically all the lines north of the Thames had been changed over. It is now stated that "the financial advantage which the trolley-'bus had previously possessed in comparison with the 'bus had diminished to such an extent that for practical purposes it could be disregarded." In view of the greater flexibility of the oil-engined 'bus, it has accordingly been decided that it shall replace the remaining trams. As, however, this will involve the conversion of tram depots and the building of new garages, in addition to the provision of the necessary vehicles, it is stated that it may be five years before the trams can be replaced.

The excellence of the work carried out by the Board and its staff and workpeople under hampering conditions is illustrated by the growth in the traffic which has been handled. In the first six years, the number of passenger journeys originating on the system rose from 3,396 million to 3,782 million. The war had an immediate effect on what had been a steady increase and by 1941, the figure had fallen to 2,857 million. There was then, however, a remarkable reversion of the trend; the position of 1933 was re-established by 1943 and by 1945 the number of journeys of 1939 was practically equalled. In the post-war years the rise continued at a rapid rate and in 1946 the figure of 4,259 million was reached. The following year, 1947, showed a slight fall to 4,243 million. The total passenger-miles last year was equal to 131 per cent. of that of 1938-1939, the increase taking place in a period marked throughout by war and post-war difficulties. The slight fall in passenger journeys in 1947 as compared with 1946 was probably due to the very severe winter of the former year and possibly also to a fall in the numbers released from the Forces, with a consequent reduction in the spending power derived from gratuities and release payments.

The question of the future of London passenger transport has now to be dealt with by the British Transport Commission. The problems to be faced, and the decisions to be taken, are of great difficulty. The decrease in passenger journeys which took place during the war was due to various causes, some of them of a type which it is to be hoped will not recur in the foreseeable future, but an important item in the overall picture was the fall in population in the area covered by the Board. This decreased from a pre-war figure of 9,888,000 to a minimum of 7,147,000. As it is the declared policy of the Government to attempt to control the growth of the population of London, and even to reduce it, by the construction of satellite towns, it is possible that a fall in population of a more permanent nature may ensue and it is certain that considerable change in the distribution of traffic loads will take place. These are not matters for the immediate future, but neither are long-distance plans for the development of transport facilities. The County of London Plan covers the elimination of the railway terminals at Charing Cross, Holborn and Cannon Street, and the redevelopment of the south bank of the river. Schemes of this sort have been discussed for 30 years or more, and the prospect of them being carried out can hardly be said to show advancement with the years, but they cannot be ignored by the new Commission in determining general policy.

* *Fourteenth Annual Report and Statement of Accounts and Statistics for the Year Ended December* 31, 1947. London Passenger Transport Board, 55, Broadway, Westminster. [Price 1*s.* net.]

NOTES.

JAMES CLAYTON FELLOWSHIPS.

WHEN Mr. James Clayton, M.I.Mech.E., the inventor of the Clayton multiple-piston spinning pump used in rayon production, died on March 6, 1944, he bequeathed practically the whole of his large fortune to the Institution of Mechanical Engineers. The Council have used a portion of the money for the James Clayton Prizes, the first of which was awarded to Air Commodore Frank Whittle in 1945. In further pursuance of the terms of the bequest, which provide that the income from the money, now in a Trust Fund, shall be expended on research, investigation, and the encouragement of modern mechanical engineering science, the Council have decided to award a number of Fellowships, to be called "Clayton Fellowships, in the course of the present year. The object of the Fellowship should be to enable the holder either to pursue an approved programme of research, or advanced studies of a post-graduate character, in mechanical engineering or a related science; or to enable him to obtain special experience or practical training beyond that of an apprentice, pupil, or trainee in mechanical engineering. The value of the Fellowship will normally lie between 250*l*. and 500*l*. for twelve months, with *pro rata* awards for shorter periods, as may be assessed by the Awarding Committee; and a Fellow will be at liberty to apply for an extension if the nature of his work justifies it. The number of Fellowships to be awarded in 1948 will depend in the number of suitable applicants, but is expected to be two or three; this, however, is not final, as the value of the awards to individual Fellows will have an obvious bearing upon the eventual number. Each candidate will be required to submit a programme indicating the use to which he will apply the award, together with an estimate of the cost of carrying it out; this should include personal expenses, but the statement should show also the amount of any other resources that he may have available. Candidates must be not less than 23 years of age and British-born, and must have obtained an approved engineering degree or have satisfied the Institution's examination requirements in some other way, and preferably should have had at least 18 months of practical training in an engineering works. Preference will be given to candidates who belong to the Institution, in the grades of Graduate, Associate Member or Member. At the completion of a Fellowship, or at the end of each 12 months, a report of work is to be submitted, and the Institution are to have the right to publish it and to hold the copyright. There are certain other regulations also to be observed, particulars of which may be obtained from the secretary of the Institution, Storey's-gate, St. James's Park, Westminster, S.W.1.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.

The future of the electricity supply industry was the principal theme of the speeches delivered at the Annual Dinner of the Association of Supervising Electrical Engineers, which was held in the Connaught Rooms, London, on Friday, April 2. Proposing the toast of "Our Guests," the President (Mr. H. Nimmo) called attention to the fact that seven of the eight living past-presidents were present, including the first holder of that office (Mr. A. H. Dykes). In reply, Mr. J. Hacking, deputy chairman, British Electricity Authority, said that in spite of the fact that the supply industry did not want the Central Electricity Board, this body had justified its twenty-one years existence. It had made great financial savings possible and these would have been greater had the generating stations been under its detailed control. The main function of the British Electricity Authority would be to organise and control generation. To begin with, the deficiency in plant must be removed; and it had been estimated that 1,500 MW of new equipment would be necessary to solve this problem by 1952. Central ownership should mean greater standardisation and thus a reduction in the time necessary for construction. Considerable progress in this direction had been effected already in connection with turbines, pipe work and valves, and this work must be continued to the greatest possible extent so long as development was not cramped. The toast of "The Electrical Industry" was proposed by Sir Cyril Hurcomb, who said that one of the first results of the change that had occurred would be that technical progress would be stimulated. In the past, the influence of individual interests had frequently led to increased cost and the waste of much time and energy. The delay in standardising tariffs was an example of the obstacles to progress which had occurred under the old arrangements and which the new legislation would do much to remove. An abundant supply of electricity was necessary if great aggregations of population were to live in small areas and if large industries were to operate efficiently. In reply, the President of the Institution of Electrical Engineers (Mr. P. Good) said that, as a whole, the industry was well organised and the Association of Supervising Electrical Engineers was playing an important part in providing competent personnel. He was not afraid that development would lag under public control of power supply; for we should be increasingly dependent on manufacturing effort.

RESEARCH ON COLD ROLLING.

Some further results of the research conducted at Sheffield University on behalf of the British Iron and Steel Research Association were given at an extra general meeting of the Institution of Mechanical Engineers, in conjunction with the Applied Mechanics Group, on Friday, April 2, with Dr. S Livingston Smith, member of Council, in the chair. Two papers were presented: "Researches into the Deformation of Metals by Cold Rolling," by Dr. Hugh Ford, B.Sc., Wh.Sc., M.I.Mech.E.; and "The Calculation of Roll Force and Torque in Cold Strip Rolling with Tensions," by Mr. D. R. Bland, B.A., and Dr. Ford. In the absence of Mr. Bland, who was unable to be present, Dr. Ford presented both papers. He said that a theory for hot and cold rolling had been developed by Dr. E. Orowan, F.R.S., M.I.Mech.E., at the Cavendish Laboratory. The present papers dealt with the practical application at Sheffield University of Dr. Orowan's findings; nearly 1,000 cold-rolling tests had been carried out with a single-stand two-high mill equipped with automatic coiler gear, variable-speed drive and a comprehensive set of instruments. Two roll-surface finishes were used: a highly-polished finish and a mat finish obtained with a comparatively coarse grinding wheel. A large number of test results had been incorporated in the first paper, with the object of providing accurate and comprehensive measurements of roll force, torque and mill power which could be used by mill designers and engineers. The second object of the experiments had been to provide suitable data for examining the effects of several independent variables on certain dependent quantities. Two empirical methods of predicting roll force or torque—known as the energy method and the lever arm method—had been put forward. The first depended on the relationship between the roll force and the energy of deformation, and the second was an improvement on the usual lever-arm method: instead of the "lever arm" (a mathematical concept, only) at which the roll force could be considered as acting being taken as half the length of the arc of contact, and assuming that the roll does not deform, the lever arm was considered as a constant fraction of the flattened arc of contact calculated by Hitchcock's formula. The third object of the research had been to examine four existing theories of rolling and methods of calculating roll force and torque—to interpret them for the rolling-mill engineer. The four methods were Orowan's exact graphical method, Orowan's homogeneous graphical method, Ekelund's method, and the Trinks-von Karman method, and the results of this examination had been fully set out in the first paper. In the paper on the calculation of roll force and torque, the authors had presented a new approximate formula which had been evolved in the course of studying existing theories. It was an approximation of Orowan's homogeneous compression theory, and it reduced considerably the time required for calculation. The same assumptions had been made, together with three additional approximations. It was evident that the latter introduced no appreciable error, since the values of roll force and torque calculated from the two formulæ rarely differed by more than 2 per cent. In comparison with experimental results, however, the calculated values were, in general, up to 10 per cent. in error in the case of the roll forces, and up to 20 per cent. in error in the case of the roll torques. The discussion on the papers was opened by Dr. C. H. Desch, F.R.S., president of the Iron and Steel Institute, who congratulated the authors on their work; Dr. Orowan made some interesting observations on the theory of rolling; and Mr. W. C. F. Hessenberg described two nomograms which had been constructed by Mr. D. A. Winton for simplifying the calculation of roll force and torque using the authors' method.

THE BIRTHPLACE OF GEORGE STEPHENSON.

It has been known for some time that the cottage at Wylam, Northumberland, in which George Stephenson was born on June 9, 1781, was likely to come into the market for sale, and various individuals and societies interested in the history of engineering, and especially of railways, have been concerning themselves with its future. As the outcome of some discussion and investigation, in which Captain E. W. Swan, O.B.E., R.N.V.R. (ret.), curator of the Museum of Science and Industry, Newcastle-on-Tyne, took an active part, the North-East Coast Institution of Engineers and Shipbuilders decided to take steps to acquire the cottage, with the intent to present it to the National Trust for permanent preservation as a memorial to the great pioneer of the railway locomotive. Some years ago, a commemorative plaque was affixed to the front of the cottage, and a duplicate of this may be seen on the main staircase of the Institution of Mechanical Engineers, of which George Stephenson was the first President on its formation in 1847. With the April leaflet of the usual notices of meetings, the Council of the North-East Coast Institution have now issued an appeal for funds to buy and repair the cottage, and to provide a sum of money for its upkeep, to be handed to the National Trust, who have agreed to accept the gift and the responsibility. The cottage has been continuously tenanted, latterly by employees of the estate on which it stands, and is in a fair state of repair. The sum of 1,200*l*., which the Council desire to raise, will not only cover the purchase of the property, which is freehold, but will enable it to be brought up to the housing standards of the local authority; this, it is stated, can be done without affecting its appearance. Contributions should be addressed to the Secretary, North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-on-Tyne, 1, cheques being made payable to "N.E.C. Inst. E. & S. (Stephenson Cottage A/c)" and crossed "Barclay & Co." We are glad to commend this appeal to the favourable consideration of mechanical and civil engineers, especially those who have associations with railway engineering or with Tyneside, and we hope that the desired sum will be reached in time to enable the transfer of the property to be made on August 12—obviously, the appropriate date, as it will be the centenary of George Stephenson's death.

ENGINEERING IN NORTH WALES.

The student of industrial administration must often suspect that the factors affecting the choice of site for a new works—so nicely balanced in text-books—are determined, in practice, by a few hard facts. It is futile to insist on establishing a new business in close proximity to the supply of raw materials or the selling market, when no suitable labour is available. Comparatively full employment and other conditions in this country since the war have induced industrialists to abandon some of the old rules, and it is therefore not altogether surprising to find that several engineering firms have opened works in North Wales, which, in contrast with South Wales, was formerly associated only with holiday resorts, agriculture and quarries. Last week, under arrangements made by the Ministry of

Supply, the Press were invited to visit several works in which production has been started since the war. Messrs. Saunders Engineering and Shipyard, Limited, have moved from Cornubia Yard, East Cowes, which was damaged by bombs during the war, to Beaumaris, Anglesey, and are now employing over 800 persons, principally on the construction of motor 'bus bodies, but also on marine craft and equipment. To enable double-deck 'buses to cross the Menai suspension bridge, some alterations were carried out on the bridge. The skill of iron founding is being imparted to men and women, recruited in Bangor, by Messrs. Sykes and Harrison, Limited, who have taken over an old works there. About 100 are employed on casting high-duty iron, and they are being trained by skilled men from the firm's Manchester foundry. A former "shadow" factory in Bangor has been taken over by Messrs. British Electric Meters, Limited, who employ about 250 people on the manufacture of aircraft instrument panels and oxygen economisers, domestic electric meters and clocks. The firm of J. K. Smit and Sons, Limited, was established in 1888, and is well known for diamond tools. The head office was moved to this country during the war, and now the unique skill necessary for the production of industrial diamonds is being taught to Welsh men and women recruited in Colwyn Bay, where the firm employ about 90 people. Diamond drilling bits for finding coal seams, etc., are among the firm's products. The last works to be visited was that of Messrs. International Refrigerator Company, Limited, at Llandudno Junction. About 350 persons are employed in the production of refrigerators in a modern factory. All the firms mentioned are having to train the majority of their employees. There is no tradition of technical skill in North Wales, such as is indigenous to Birmingham, for example, but it is generally agreed by the managers that the men and women are amenable to training, and, in particular, are not prejudiced against certain industries and conditions of employment.

LETTERS TO THE EDITOR.

SCHOOL OF GAS TURBINE TECHNOLOGY.

To the Editor of Engineering.

Sir,—It may be of interest to some sections of your readers to know that this Company have taken over the School of Gas Turbine Technology at Ladywood Works, Lutterworth, hitherto run by the National Gas Turbine Establishment with conspicuous success. The School is closed until May 31, 1948, for reorganisation, the complete revision of syllabus, and the preparation of new lectures for courses in Industrial Gas Turbines and kindred subjects. It is proposed to have academic courses for graduate engineers, as before. There is room for some degree of specialisation here—for example, in the various specific fields of compressor theory and design, combustion, etc., for which demand exists, but is difficult to assess. We also propose to arrange practical courses for draughtsmen, testers, engineers and operators, as may be indicated by the demand. Your readers would greatly help us to help them if they could give any indication of the demand for such specialised, or practical courses.

We may be allowed to add, perhaps, that there is no profit motive represented in the operation of the School, the object of which is mainly to meet the wide public need for accurate and sound instruction in gas-turbine technology. Consequently, the cost of attendance, which might at first be thought to be high, is fully justified by the value afforded. Inquiries, or the suggestions we seek, should please be addressed to the Company as below.

Yours faithfully,

For Power Jets (Research and Development), Limited,

W. E. P. Johnson.

8, Hamilton-place,
London, W.1.
March 31, 1948.

ENGINEERING UNITS OF FORCE.

To the Editor of Engineering.

Sir,—I think that Mr. Helmer's letter in the issue of Engineering for March 19, 1948, page 280, should not go unchallenged. The crux of this matter of force and mass is contained in Mr. Helmer's statement (referring to these two quantities) " . . . the difference is not one of size but of essential nature." Nevertheless, Mr. Helmer spends considerable time in an endeavour to produce a mathematical equation containing both force in lb. and mass in lb. This, of course, is impossible without employing the subterfuge of a "constant" which in a strictly mathematical sense is not a constant at all.

Surely the correct approach to a proper understanding of the formula $F = m\,a$ is to apply the all-revealing method of using non-dimensional symbols. The formula can then be written $W = \frac{m \times S}{T^2}$, where W = weight or force, S = distance, and T = time.

From this we get $m = \frac{W\,T^2}{S}$.

If W is measured in lb., poundals, grams or any other recognised unit of weight, it is obvious that mass is a function of weight, time and distance. Further, if W is measured in lb. and acceleration in ft./sec.^{2}, m must be measured in lb. sec.^{2}/ft.

The obvious practical way to deal with the formula $F = m\,a$ is to convert it to

$$F = W \times \frac{a}{g}, \text{ or } F = \frac{W}{g} \times a.$$

This is the only form in which the formula can be mathematically possible and yet allow of the use of the lb. (or any other similar unit) on both sides of the equation. To sum up, if use is made of the lb. as a unit of force or weight, the unit of mass cannot also be the lb. What is loosely and commonly referred to as a mass of x lb. is actually a mass of $\frac{x}{32{\cdot}2}$ lb.sec.^{2}/ft.

Yours faithfully,

R. H. Young.

54a, Creffield Road,
Colchester, Essex.
April 1, 1948.

PROFESSIONAL SALARIES.

To the Editor of Engineering.

Sir,—I am sure that Mr. D. S. Chubb did not intend to mislead, in his letter which appeared on page 304, *ante*, as, had he been acquainted with the agreement which exists between the Association of Scientific Workers and the Association of Supervisory Staffs, Executives and Technicians, surely he would not have made the statement that "the A.Sc.W. is not the appropriate organisation for all professional engineers" and the inference that the A.S.S.E.T. is the correct organisation.

To clear up any misunderstanding, may I make it clear that the agreement between the two organisations recognises that "all professionally qualified scientific workers should be organised in the A.Sc.W. ? (Professional qualifications being the possession of degrees or equivalent diplomas in science or engineering, or by other diplomas together with adequate professional experience)." The agreement also recognises that "technicians on production and inspection should, where eligible, be organised in the A.S.S.E.T."

Yours faithfully,

C. T. Wilshaw, A.I.M.,
Chairman, Engineering and Metallurgical Committee, Association of Scientific Workers.

15, Half Moon-street,
London, W.1.
April 3, 1948.

The Institution of Naval Architects: Designations of Membership.—The Institution of Naval Architects contains four classes of membership, namely, Member, Associate-member, Associate and Student. The Council of the Institution have recently revised the abbreviations to be used to indicate these grades, which are now, respectively, M.I.N.A., A.M.I.N.A., Assoc.I.N.A. and Stud.I.N.A.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 331.)

We continue below our report of the Spring Meeting of the Institution of Naval Architects, on March 17 to 19. At the afternoon session on March 18, the two papers presented were that of Commander (E) A. D. Bonny, R.N., on "The Effect of Non-contact Explosions on Warship Machinery Design"; and one on "German U-Boat Design and Production," by Constructor-Commander J. F. Starks, R.C.N.C.

Non-Contact Explosion Damage to Warship Machinery.

Explosions of non-contact mines and of near-miss bombs caused shock damage to more than 100 ships during the war, said Commander Bonny, and much of this damage was of a serious nature; failure of iron castings formed the greatest part of the damage, though considerable subsidiary damage and derangement was caused by the tripping of governors and defects in circuit-breakers, lighting and other electrical equipment, gyro-compasses, etc. The Admiralty Shock Committee was formed, therefore, to investigate the problem in theory and experimentally. Full-scale experiments were carried out on the destroyers Cameron and Ambuscade, and on the submarine Proteus, and investigations into the effect of larger ships were being pursued. A charge of 300 lb. of T.N.T. (or equivalent explosive) in a container under water changed in about $\frac{1}{4000}$ sec., on detonation, into an equal volume of gas at a very high temperature and at a pressure of the order of 1,000,000 lb. per square inch. The rapid initial rise of pressure, followed by expansion, caused a pressure pulse in the water, travelling at about 5,000 ft. per second. The outward velocity of the water surrounding the expanding bubble caused it to over-expand; the gas pressure then fell below the hydrostatic pressure and the water forced the bubble to contract. This action might repeat several times, each time sending out a new pressure wave. The effect on a ship of the blows resulting from the impact of these shock waves was to induce accelerations ranging from several thousand g in the case of shell plating down to $2\,g$ to $5\,g$ in the ship whipping as a whole; items of machinery mounted directly on frames would have accelerations of $100\,g$ to $300\,g$. Consequent damage could not be avoided entirely, but might be restricted so as to reduce the amount of damage that could not be readily repaired. It was necessary, therefore, to design items of equipment to withstand the effects of violent acceleration; for example, the average piece of auxiliary machinery should be able to withstand $120\,g$ upward, $60\,g$ downward, and $40\,g$ to $60\,g$ in an athwartship direction. The prohibition of cast iron except where its properties warranted its special retention was an obvious step, but could not be implemented fully because of wartime production difficulties. Cast aluminium was a similar source of weakness, but gunmetal was better if sufficiently ductile. Resilient mountings were employed also, with some success, but were not always practicable; shearing devices were also used, designed to remain rigid until, under shock conditions, the load exceeded a certain value. In presenting the paper, Commander Bonny added, with regard to the velocity: time curves, that it had been found in practice that the simple velocity meter gave the best form of record.

The discussion was opened by Sir Stanley V. Goodall, who said that the impression conveyed by the author's introduction—that the Admiralty were not greatly concerned about shock effects until, in the recent war, they were confronted by the serious damage caused by magnetic mines—was not correct; there had been considerable discussion after the 1914-18 war about the effects of underwater explosions. Experiments had been made with ex-German submarines; and a section of a modern capital ship, as conceived at that time, was built on H.M.S. Monarch, and a very big charge was exploded close to the ship, under the bilge. Some useful lessons were learned and applied, but one which was not fully appreciated was the brittleness of cast iron. When he had become directly responsible, said Sir Stanley, he had discussed with the then

Engineer-in-Chief the amount of cast iron in ships, and was assured that, at that late stage, any such change as had been discussed would have delayed the re-armament programme very seriously. The damage to H.M.S. Belfast, however, suggested that less was known about the matter than had been supposed. On the advice of the then Director of Scientific Research, Sir Geoffrey Taylor examined the results produced and sent in a mathematical treatise, indicating that the secondary pulse, referred to in the paper, was something which had not been regarded. It had been thought that the extremely high pressure in the first pulse and the time over which that pressure lasted, being known, it should be possible to estimate the damage, which was a function of pressure and time; Sir Geoffrey had pointed out, however, that the secondary pulse might produce a lower pressure, but would be extended over a greater time, and that the bubble would be rising, so that it might be nearer the hull. Thus it was considered that the much more extensive damage to the Belfast was due to the secondary pulse.

Mr. D. E. J. Offord paid tribute to the small team of specialists whose work and enthusiasm had produced the results given in the paper. Most of the tests were made in a relatively lonely loch in northern waters, involving working in small open boats to fit explosive charges and to lay recording instruments and cables; and then crawling into the less accessible corners of unlighted ships, over oil-covered structures and often with flooding gaining on the pumps. He agreed with most of the points in the paper and emphasised the value of the results presented; but a word of caution was needed as to how far it was safe to go in applying them. Referring to an appendix on the calculation of the effect of a pressure pulse on an unrestrained flat plate and its relation to the effect on items of machinery and equipment, he said that some basic assumptions were made, none of which was in strict accord with the experimental data; but they did lead to equations of motion which were susceptible to exact solution by simple mathematical treatment. The formulæ derived from those, and other assumptions, had helped materially to clarify ideas on the complex subject of shock, and accorded well with the experimental evidence, provided that they were handled by experts fully conversant with their limitations. So far, they had been applied to single-hulled ships of relatively simple construction; it remained to be seen whether they would prove equally satisfactory for more complex designs.

The paper conveyed the idea that the disastrous consequences of shock damage came as a "bolt from the blue" early in the second world war. That was not quite true, and it contained an important lesson. Shock damage was first found and its importance realised during trials with non-contact under-water explosions against warships in 1920. The matter was taken up again in 1936 and some preliminary trials carried out. Early in the second World War, a proposal was made to use an operational minesweeper to obtain records of shock phenomena, and that was the real beginning of the present trial technique; but it needed the heavy losses of the early days of the war before personnel and facilities were provided on an adequate scale. The lesson was, of course, that the research should be done in the years of peace; and it must be directed by practical men who were aware of the shortcomings of the ships, machinery, weapons and other equipment. It might be uneconomical, and possibly impracticable, to apply to merchant ships all the safeguards considered necessary in warships; but much could be done and he suggested that if, in normal design, consideration were given to ability to resist shock, it would often result in generally improved and more efficient equipment without increase in weight or cost.

Mr. H. F. Sherborne referred to his inspection of the joints of certain of the piping systems, in particular the light-gauge copper piping systems, in the Belfast in March, 1940; there were light-gauge copper pipelines joined by the then fairly new capillary kind of fitting. Having inspected the job throughout, he had found that, with only four exceptions, the joints had held. That was more remarkable than it appeared, when related to the events on the ship. The condition of the piping system served to emphasise the point made by the author concerning the value of ductile material.

Mr. J. E. Shaw amplified the author's statement that certain damage was caused by the initial pressure pulse, and said the pressure pulse (apart from bubble interference) was responsible for all subsequent shock movements. He did not quite agree that even an appreciation of the accelerations on a machine could be obtained from considerations of the behaviour of an unrestrained flat plate having the same mass per unit area of supporting hull as the machine when that arrangement was subjected to the pressure pulse, as the accelerations were a function of both the directly transmitted forces caused by the pressure pulse and the forces caused by local distortions of the shell plating relative to the framing, etc. He recalled that, in 1942, Commander A. J. H. Goodwin had summed those forces on a main gearcase and on a turbo-alternator in one of H.M. ships, for certain non-contact under-water explosions, and, by a laborious step-by-step method, had reproduced almost exactly the velocity: time records obtained experimentally, thus indicating that it was possible to predict shock movements, acceleration and velocities in certain cases. The type of failure mainly dealt with in the paper was that caused by relative motion between different parts of the same item, leading to excessive strain where there were large bending moments and causing fracture if the material were brittle and distortion if it were ductile. Little mention was made of failure caused by relative motion between independent components of an item. Such motion might lead to mechanisms failing, collision between separate components causing incorrect operation and failure of mechanisms or switchgear. That type of failure was difficult to predict, and indeed, shock testing was generally necessary to ensure trustworthiness of mechanisms.

Mr. A. R. Mitchell emphasised the importance of weight limitation, and wondered whether it was possible to concentrate more on resilient mountings immediately under the machinery, and to leave the hull structure with present scantlings and present resilience. Shock must be covered, but he felt that the weight was going up to such an extent that some compromise was necessary.

Mr. D. M. Baker said that, when a designer was given figures for acceleration, he would ask if he had to design a part of a ship to which a machine was attached to withstand a certain loading; if he tried to do that, the ship would probably be so heavy that it would sink. The answer was that the accelerations had been obtained on existing ships, and, in general, though not invariably, one should retain the existing type of seating. Generally, it would be found that the existing seatings were up to standard; but if they were not, very little harm was done, and generally it was a good thing to have a certain amount of resilience and possibly a certain amount of play in the seatings. Dealing with the author's reference to the dynamic yield strength of materials, he said he would have felt happier if it had not been associated directly with the rate of strain, but rather with the duration of loading.

Mr. S. Archer, having inspected the full-scale equipment in H.M.S. Cameron in 1943, said that that ship was an elaborately equipped floating laboratory. Various units of auxiliary and main machinery were fitted in special compartments of the hull, those being mounted on bearers directly on the bottom and side framing. Three main types of instrument were employed for recording the motion of the various units resulting from the pressure impulses on the hull of the vessel, namely, displacement recorders, which were of purely mechanical design, being either of the vibrating-cantilever type or the rotating seismic-cylinder type; electro-magnetic velocity recorders of the seismic type; and accelerometers, either of the piezo-electric type or —a cruder form—consisting of a small copper pellet inserted between the top surface of the machine and a free heavy mass. The amount of compression of the pellet as found by micrometer was a measure of the maximum acceleration imparted to the machine. He asked for information concerning the behaviour of those various types of instrument, and which type was most successful for measuring the extremely high accelerations involved. He asked also whether hydraulic damping devices of the dash-pot or similar types had been tried out, and whether dry friction damping had been fully explored as a means of limiting vibration amplitudes.

Although the means of protection against damage from under-water explosion that were found practicable in merchant ships were probably much less efficient than in naval vessels, the measures taken had proved to be well worth while. Among the principal safeguards were the fitting of non-return valves to open ends of bilge suctions; bracing of ship's-side valves, and the use of cement boxes for the protection of existing cast-iron valves and fittings; the adoption of fabricated construction for ship's-side valves exceeding 6 in. in diameter; the use of thick rubber gaskets for pipe joints; and remote control of principal stop valves and ship's-side valves in case of flooding. As a reflection of war-time experience, Lloyd's requirements now specified that ship's-side valves and fittings were to be of cast steel or equivalent material, except where less than 3 in. in diameter.

Mr. M. F. Gunning, who had attended some of the trials in the deep loch in Scotland, referred to in the paper, thought that it might be possible to extend the idea of special lengths of holding-down bolts by fitting them to other things such as junction boxes; a sort of mounting which would allow of plastic deformation.

Mr. K. G. Evans, commenting on Mr. Archer's reference to the use of cement boxes to protect the sea cocks on merchant ships, said that those cocks had proved to be a very great source of weakness during the early magnetic-mine attacks against shipping. Many German ships had been lost because they had not made adequate provision for protecting sea cocks. It was also found that many had been wholly incapacitated because the piping systems had been wrenched, and he asked whether, in this country, attention had been given to putting piping systems near the neutral axis.

Commander Bonny, replying to Sir Stanley Goodall's reference to Sir Geoffrey Taylor, said that even though there was in many cases a secondary pulse and bubble effect, it was not always so, and severe damage could be done equally, or even more so, by the first pressure pulse. Dealing with Mr. Offord's remarks: he had done his best to put forward a method which would give an idea of the mechanism, but recognised that it was not a complete set-out of the motions in a ship as the result of under-water explosions. He hoped that Mr. Offord and his Establishment would be able in due course to produce a more exact formula. He agreed that practical men should work with the scientists to ensure that useful results were obtained and applied, and that not scientific data alone resulted. The results mentioned by Mr. Sherborne concerning the piping in the Belfast were not unreasonable, for the pipelines were relatively light and relatively ductile; ductility would go a long way to avoid damage. In reply to Mr. Shaw's remark about the acceleration formula, Commander Bonny said that he had indicated in the paper that a free plate did not serve as a very useful guide. Regarding the increased weights resulting from the figures of shock acceleration mentioned by Mr. Mitchell, he agreed that it was a matter for compromise; but the effects on a ship were such that not much could be given up, when considering the design of turbine seatings. Dealing with Mr. Baker's remarks on seatings, he said that, in many cases, machines were self-contained and some distortion of the seatings was probably acceptable. In such a case, a relatively weak seating was probably of advantage. As to the dynamic yield stresses, it was known that the rate of application and the duration of loading had a considerable bearing; further trials were in progress.

The President, proposing the thanks of the meeting to Commander Bonny for his paper, said that the importance of the problem had been brought home to him very forcibly when he had seen a destroyer come into Alexandria harbour with her turbines fractured, due to a near miss by a bomb and some not so near; the vessel was out of action for months.

(*To be continued.*)

THE PHYSICAL SOCIETY'S EXHIBITION.

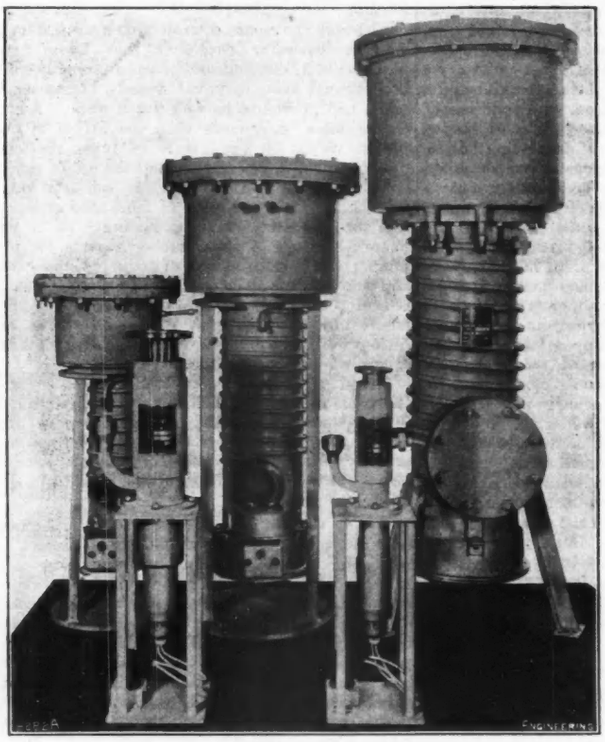


Fig. 1. High-Vacuum Coating Unit; Messrs. Metropolitan-Vickers Electrical Company, Limited.

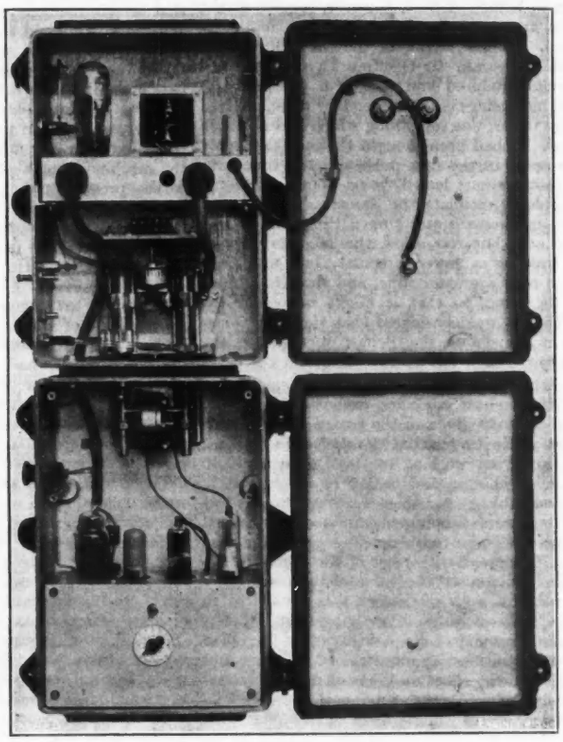


Fig. 2. Infra-Red Gas Analyser; Sir Howard Grubb, Parsons and Company.

THE PHYSICAL SOCIETY'S EXHIBITION.

The 32nd exhibition of scientific instruments and apparatus organised by the Physical Society was opened at the Imperial College of Science and Technology, South Kensington, London, S.W.7, on Tuesday, April 6, and remains open until to-day, Friday, April 9. As was the case for the first time last year, the exhibition was open for four days instead of three. On this occasion, however, proceedings did not begin until the afternoon of the first day, when a formal opening ceremony was conducted by the President of the Board of Trade (the Rt. Hon. J. A. Wilson, M.P.). Moreover, the morning sessions on the other days have not been reserved for members of the Society and special visitors. This has resulted in considerable congestion in rooms which are not ideal for the purpose of an exhibition, and this is not surprising since we understand that more than 12,000 admission tickets were issued.

Among the exhibits of Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, who were represented in both the trade and research sections of the exhibition, mention may be made of the high-vacuum coating unit, an illustration of which appears in Fig. 1. This unit is intended for the preparation of reflecting and non-reflecting films by the process of evaporation, and also for the deposition of films of a wide variety of metals. It is automatic in operation and is therefore suitable for use by semi-skilled personnel. It consists of a control desk (not shown in the illustration) and a pedestal. The latter contains a vacuum chamber which is evacuated by an oil-diffusion pump backed by a rotary pump. The former pump has a capacity, when used with its water-cooled baffle, of about 250 litres per second at 1×10^{-6} mm. of mercury absolute. The connections are provided with double-ring rubber-sealed vacuum flanges which permit the tightness of the joint to be tested without disturbing the pump. The heater is rated at 1,000 watts; the element is the same as that used in the firm's enclosed boiling plates. The pump is water-cooled and a flow of about 1½ gallons per minute is required for each plant. A vacuum valve is fitted on the inlet of the diffusion pump and a rough pumping line is supplied to the rotary pump. The latter is of the Kinney rotating plunger type with a single cylinder, the theoretical displacement being 5·9 litres per second at the normal speed of 430 r.p.m. It is driven by a 1-h.p. three-phase induction motor through a V-belt.

The cycle time required for deposition varies from about 30 minutes on a single-chamber plant to 10 minutes on a twin-chamber unit. The operation consists of mounting the glass, or other material to be coated, in the vacuum chamber and exposing it to a stream of metal particles the temperature of which is such that they adhere to the glass and form a reflecting film. It is essential for the process that the vacuum in the chamber shall be high enough for the mean free path of the metal atoms to be large compared with the dimensions of the apparatus. The pumps must also be of sufficiently high capacity to evacuate the hydrogen generated by the decomposition of the water vapour which takes place when some of these atoms react with the gas film absorbed on the surface of the chamber.

A new model of their infra-red gas analyser is exhibited on the stand of Sir Howard Grubb, Parsons and Company, Walker Gate, Newcastle-upon-Tyne, 6. The operation of this instrument, which is illustrated in Fig. 2, depends on the fact that most of the common gases have strong absorption bands in the infra-red region of the spectrum. If, therefore, radiation is passed through an absorption tube filled with dry air free from carbon dioxide, some of it will be absorbed. As a result, the gas will be heated and there will be an increase in pressure. On passing air containing a small proportion of carbon dioxide into the absorption tube, some of the radiation, which previously reached the detecting cell, will be absorbed and the response will be reduced. The introduction of other gases into the absorption tube has no effect on the detecting vessel, unless these gases happen to absorb wavelengths common to carbon dioxide.

This principle is used in the gas analyser exhibited by passing infra-red radiation from two electric heaters through absorption tubes and thence to receiving vessels which are filled with the gas to be detected. A rotating shutter allows the radiation to pass intermittently, but simultaneously, through the two tubes and a heating effect is thereby produced in each of the receiving vessels. These vessels are separated by a thin metal diaphragm, close to which is an insulated and perforated plate. An electrical condenser is thus formed, the capacity of which is altered by any deformation of the diaphragm which results from a difference in the pressure in the two receiving vessels. If no absorption occurs in the absorption tubes, the heating effect in the receiving vessels, and therefore the pressure in them, will be equal. When the gas to be detected is introduced, this balance will be upset since radiation is absorbed by the gas in one tube before it can reach the other, owing to the action of the shutter. The resulting change in the capacity of the condenser is amplified and indicated on a meter which is carried on the upper door of the cabinet. This meter can be calibrated to suit the particular gas and concentration range required.

Considerable interest attaches to the Vampire alternating-current test set which is exhibited by Messrs. Everett, Edgcumbe and Company, Limited, Colindale Works, Hendon, London, N.W.9. This, it is claimed, provides for the first time an instrument which can be used under industrial conditions for measuring current, voltage and power in an alternating-current circuit without changing the connections. It also possesses all the advantages of a robust critically-damped moving-coil permanent-magnet indicator; and, in view of its low burden, should be particularly useful for measuring power at low power factors when the total capacity is small. As the damping is critical, peak currents, such as the starting currents of small motors, can also be measured accurately. It is designed for dealing with voltages between 0 and 250, while

THE PHYSICAL SOCIETY'S EXHIBITION.

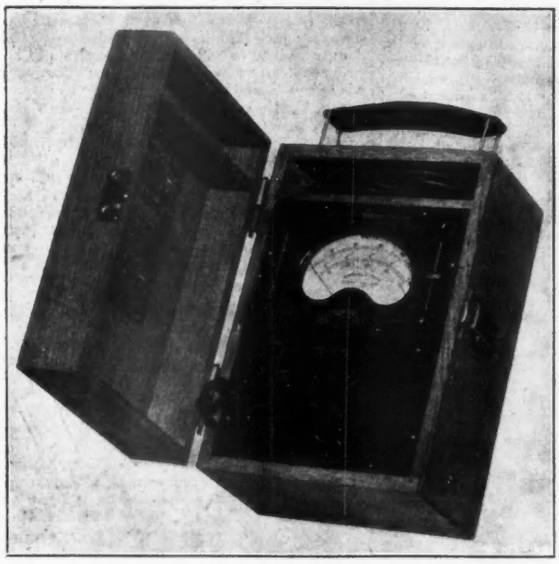


FIG. 3. ALTERNATING-CURRENT TEST SET; MESSRS. EVERETT, EDGCUMBE AND COMPANY, LIMITED.

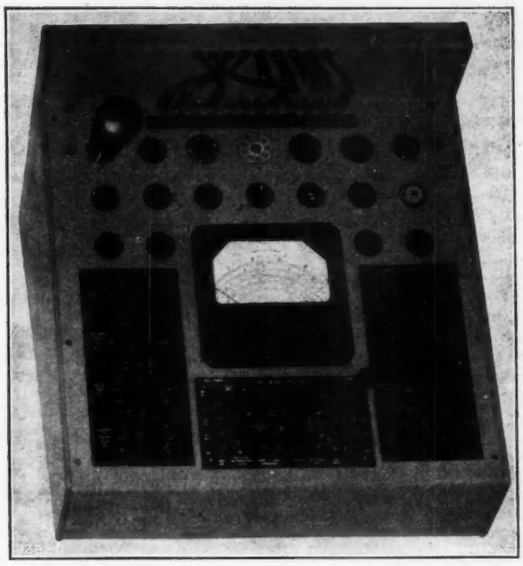


FIG. 4. SERVICE VALVE TESTER; MESSRS. EVERETT, EDGCUMBE AND COMPANY, LIMITED.

Fig. 5.

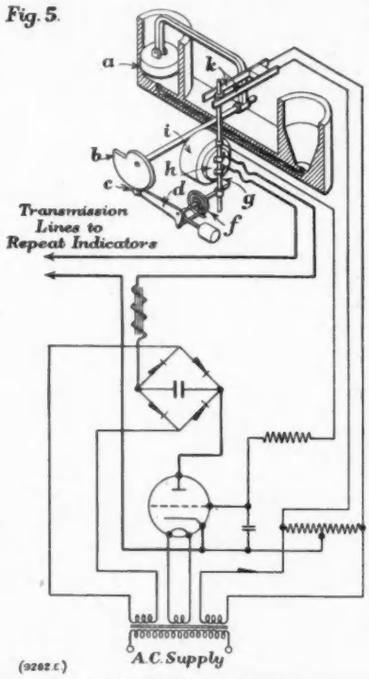
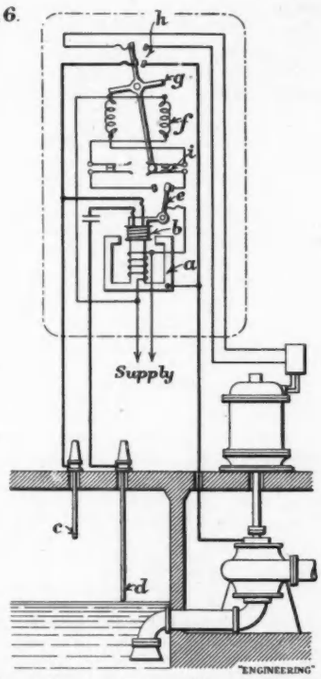


Fig. 6.



FIGS. 5 AND 6. WATER-FLOW TRANSMITTER AND PUMP-CONTROL UNIT; MESSRS. EVERSHED AND VIGNOLES, LIMITED.

four current ranges, 0 to 0·2, 0 to 1, 0 to 5 and 0 to 20 amperes, are available, the corresponding watt ranges being 0 to 50, 0 to 250, 0 to 1,250 and 0 to 5,000 watts single phase. The power consumption is about 0·25 volt-amperes.

The essential feature of the instrument, which is illustrated in Fig. 3, on this page, is a phase-sensitive, rectifier bridge network from which the necessary operating current is derived. By means of this network the voltage wave is applied to a pair of rectifiers, so that the direct-current component is equal and opposite in the two half cycles. At the same time, the current wave, which is applied to the indicator terminals of the bridge, increases the apparent output in one half cycle and decreases it in the next, depending on the phase relationship between the current and the voltage waves. Thus the current passing through the indicator is proportional to the product of current and the cosine of the phase angle between the voltage and current waves. An interesting feature is that the deflection of the instrument is independent of the amplitude of the voltage wave. By employing non-linear resistors in the network, however, the effective resistance can be reduced in proportion to the rise in voltage, thus making the deflection proportional to $E I \cos \phi$. This compensation applies over a range of 200 to 250 volts. Demonstrations given during the exhibition showed that the phase-sensitive rectifier network can also be employed for measuring frequency and power factor.

Messrs. Everett, Edgcumbe are also exhibiting the service valve tester, which is illustrated in Fig. 4. This is designed for testing all types of radio valves in general use and for operation on 200 to 250 volts and 40 to 100 cycle circuits. The control panel is sloping and, as will be seen, carries a 4-in. flush moving-coil indicator, 14 British and American valve holders, and the necessary control switches, those on the left controlling the voltage and those on the right the various tests. The power pack is carried on a metal chassis below the panel and is wired to the row of sockets visible along the top. The appropriate numbered plugs, which are connected by retractable flexible leads to the corresponding valve pins, are inserted in these sockets. The supplies to the filament or heater are obtained from a transformer, which is designed to give good regulation at varying loads and is provided with a tapping switch to give eleven different voltages between 1·5 and 117 volts. The grid supply is obtained from a metal rectifier with potentiometer control, while the anode and screen grid supply is direct-current at 20, 50, 100, 150, 200 or 250 volts. For screen dissipation tests the anode can therefore be held at a low potential. As an example of the use to which this instrument can be put, mention may be made of the cold insulation test in which a potential of 50 volts is applied between each electrode in turn, the remaining electrodes being strapped together. The sensitivity of the indicator under these conditions is such that the deflection is easily observed when the resistance is of the order of 5 megohms. Valves may easily be matched by measuring their mutual conductance. This is obtained by determining the corresponding difference in the anode current when the control grid potential is altered by 1 volt at any point in the working range. Thyratrons can also be tested for emission by means of a built-in load resistor. The negative grid supply then permits the control ratio, i.e., the ratio of anode to grid volts, necessary for arc initiation to be measured.

Messrs. Evershed and Vignoles, Limited, Acton-lane Works, Chiswick, London, W.4, are showing applications of their electronic repeaters to the measurement of water and gas flow. In the water-flow transmitter, which is illustrated diagrammatically in Fig. 5, a differential unit made by the British Pitometer Company is utilised as the originating movement. The primary spindle of this movement is operated by a stainless-steel float *a*, which is contained in a chamber filled with mercury and drives a cam *b*, which converts the differential

pressure into units of flow. A roller *c*, which is fitted to the end of a lever *d*, is pressed against the periphery of the cam by a counterweight. A spiral spring *f*, which is connected between this lever and the transmitter pointer *g*, converts any deflection of the lever into a torque. The transmitter pointer carries a coil *h*, which is connected in the anode circuit of a triode valve and works in a pot magnet *i*, the circuit being completed through distant indicators and recorders which are connected electrically in series. The contact carried by the arm *g* is connected to the grid of the valve, while the two outside contacts carry positive and negative biasing voltages, respectively, so that the anode current of the valve can be altered as required. The current through the coil is normally such as to provide an equal and opposite torque to that exerted by the quantity under measurement, in this case the flow. If the quantity, and hence the torque, changes, however, the arm moves over and one of the biasing contacts is made. The anode current is thereby increased or decreased as required until the two torques are again balanced and the moving contact returns to the central position. As will be seen from Fig. 5, a condenser and resistance are connected across the grid circuit of the valve to store the required biasing voltage. The system thus supplies a direct-current, which is proportional to the flow in the differential unit and can be indicated at a distance through the transmission lines.

The same firm are exhibiting an improved pattern of their "Noflote" control system for automatically operating electrically-driven pumps without the use of floats in accordance with variations in the water level. In this system the relay unit has been designed so that control can be effected through comparatively pure water. For instance, while with the original pattern of relay a potential difference of 60 volts was necessary across the electrodes, and operation was possible through a water resistance up to 300 ohms, in the new instrument only 12 volts is necessary for a resistance of 3,000 ohms. The method of operation of the system is shown diagrammatically in Fig. 6, on page 355. As will be seen, an electromagnet *a* is connected to the 230-volt mains and acts as the primary of a transformer. The secondary of this transformer consists of the coil *b* from which a supply of current at 12 volts is applied to the electrodes. This coil is mounted on spring-urged jewels and is free to move into the air gap of the electromagnet. It is connected in series with a condenser, the purpose of which is to bring the current in the coil and the field of the electromagnet into phase. When the water in the sump completes the circuit through the two electrodes *c* and *d* the coil *b* is energised and is drawn into the gap of the electromagnet *a*. The moving contact *e* is thus caused to change over from one fixed contact to the other, so energising the appropriate coil of the secondary relay *f*, which tilts the armature *g*, closes the contact *h* and breaks its own circuit at *i*. The upper contacts at *h* operate the starter of the pump motor, while the lower contacts complete the hold-on circuit through earth. The pump therefore continues to run until the water falls clear of the lower electrode *d*. The coil *b* is then de-energised and the centre contact *e* changes over

(To be continued.)

CAMBRIDGE SUMMER SCHOOL IN METAL PHYSICS.—A summer school in metal physics will be held from Monday, August 23, to Friday September 3, in the Cavendish Laboratory, Cambridge. The school will provide an introduction to the application of physical methods to the examination and utilisation of metals, and is intended for those whose researches require a more fundamentally physical approach than is usual in ordinary metallurgical and engineering practice The lectures and demonstrations will deal with (*a*) the application of X-ray methods in the examination of metals, and (*b*) the physical and mechanical properties of metals. Both (*a*) and (*b*) will be taken by all attending the school, and for (*a*) an elementary knowledge of X-ray diffraction methods and of crystal symmetry will be assumed; during the school week it will be possible to provide only a very brief review of these aspects of the subject matter. A detailed syllabus and form of application for admission may be obtained from Mr. G. F. Hickson, M.A., secretary, Board of Extra-Mural Studies, Stuart House, Cambridge, to whom the completed application form should be returned not later than Tuesday, June 1.

LABOUR NOTES.

THE annual conference of the Union of Shop, Distributive and Allied Workers at Blackpool unanimously adopted a resolution approving the action of the executive in voting against the endorsement, by the General Council of the Trades Union Congress, of the proposals on incomes, prices, and profits in the Government's White Paper. The resolution affirmed the union's confidence in the Labour Government, but claimed that to stabilise wages while the cost of living continued to rise would bring hardship to thousands of people. It called for a rigorous control of prices, a rigid limitation of profits, and the introduction of a minimum wage throughout industry. Mr. A. W. Burrows, acting general secretary, said that the union would exercise restraint, but would insist on its right to negotiate whenever it felt that a case could be made out for an increase in wages.

The conference decided that more attractive wages and conditions should be negotiated immediately for the distributive trade, and that the executive should aim at an increase of at least 1*l*. a week for all adult workers. It was also agreed to seek an increase of 25*s*. a week in the minimum rates of men and women laundry workers.

A reference in the latest *Trade Report* of the United Patternmakers' Association has some bearing on this point. Mr. Beard, the general secretary, says: "It will be within the knowledge of members that the engineering and shipbuilding workers, through the Confederation of Unions, have been employed for a considerable time in designing a new wage structure which safeguards existing differentials; but, whilst this wage structure has been under consideration, many workers in occupations not so short of man-power, and not so important, have received increases in wages which have thrown the engineering worker completely out of line and lowered his living standard."

"The restraint which the White Paper requests on wage applications has been exercised," he writes, "by the engineering workers, where wages have remained static for two years or more, and it is, therefore, understandable to some extent that they have decided to proceed with their application. There is no doubt that a case for adjustment can be made, particularly as these workers are retained in their industry, many against their will, and cannot leave to obtain employment in other less important industries where labour is required and wages are higher. To make comparisons would be odious, but the fact remains that workers in industries which are less skilled and which have greater security, are better paid."

A resolution adopted at the Margate conference of the Association of Engineering and Shipbuilding Draughtsmen urged the Government to take immediate action to set up joint production committees throughout industry, and to give them powers to overcome any obstacles to full production. During the discussion, it was alleged that obstructionist tactics were being used by some employers.

According to the Cotton Board's Labour Department, an experiment in the redeployment of labour in the card room at Musgrave Mill, Bolton, resulted in a 15 per cent. increase in output an hour, a 39 per cent. increase in production a man-hour, a wage increase of 30 per cent., and a reduction in labour cost per lb. of cotton of 10 per cent. Industrial consultants, it is stated, proposed a plan which was approved by the operatives, their trade union and the mill management. The duties of operatives were re-arranged, the lay-out of some of the machinery was changed, and the number of machines to each tenter was increased.

The method of payment was changed from day rate to an incentive scheme which allowed a wage of 4*l*. a week for men, and for women, a wage ranging from 3*l*. 2*s*. to 3*l*. 5*s*. a week. Bonus rates enabled an experienced employee to earn a further 30 per cent. As a result of the redeployment, the number of operatives required was reduced by 21 per cent., and the time devoted to the general supervision of work and relaxation from duties was increased.

Officially-compiled figures relating to the coal-mining industry show that the total production in the first 12 weeks of 1948 amounted to 49,403,800 tons, compared with 45,571,400 tons in the corresponding period of 1947. This year's weekly average is 4,117,000 tons, whereas 4,220,000 tons is required each normal week to reach the target of 211,000,000 tons for 1948. In the week which ended on March 20, absenteeism among coal face miners was 7·23 per cent., compared with 7·97 per cent. in the previous week.

Under the Factories Bill which was formally presented to the House of Lords last week, the power of courts of summary jurisdiction to deal with factories that are dangerous is to be widened. The courts will be able by Order to stop or prevent the use, as a factory, of premises which are unsuitable from the point of view of the safety, health, or welfare of the employees. In future, "as a general rule," anyone intending to occupy a factory, or use mechanical power for the first time, will have to give a month's notice of his intention to do so. "Seating facilities," which, under the 1937 Act, have to be provided "during opportunities of rest for all female operatives whose work is done standing," are now to be provided for all employees, and seats are to be found "where a substantial proportion of any work can properly be done sitting."

Under an agreement to which the London Transport Executive and the Transport and General Workers' Union are parties, inspectors and foremen are to receive wage increases. Men in most grades are to receive an extra 5*s*. a week, and, in future, time and a half is to be paid for Sunday work, instead of time and a quarter.

On April 12, it is announced, representatives of the engineering trade unions belonging to the Confederation of Shipbuilding and Engineering Unions, are to discuss their application for increases of wages with the Engineering and Allied Employers' National Federation. A national minimum wage of 5*l*. 15*s*. a week is claimed for skilled operatives and one of 5*l*. a week for labourers. Details of the proposed new wage structure for the industry will also, no doubt, be considered. The claim of the Confederation's shipbuilding unions is to be considered at a conference with the Shipbuilding Employers' Federation on April 21. Here, the application is for 5*l*. 19*s*. a week for craftsmen and 5*l*. a week for labourers, representing a 15*s*. a week advance for all. The four unions which have women members employed in engineering are also seeking wage increases. They are asking for an advance of 14*s*. 6*d*. a week which would raise the maximum time rate to 3*l*. 17*s*. a week. Women doing mens' work at rates which have a fixed relationship with those of men doing the same job, are not included in this application.

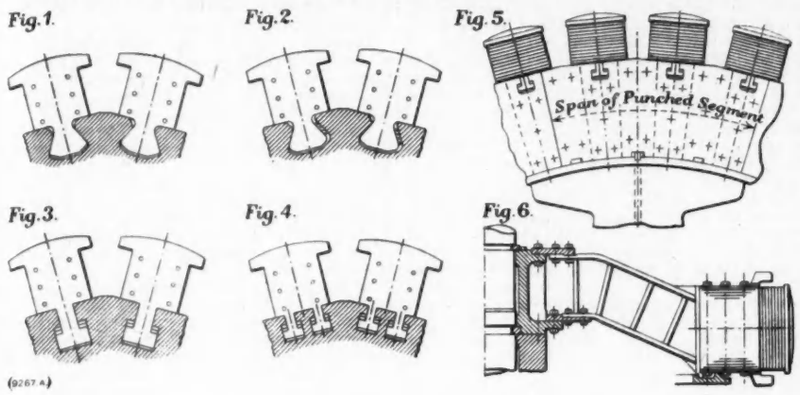
A resolution which is to be discussed at the Liberal Party Assembly, at Blackpool, this month, includes a proposal for compulsory co-partnership in industry. It calls for legislation requiring every industrial concern with a capital of not less than 50,000*l*. and/or not fewer than 50 employees, to submit for approval by a commission a scheme embodying certain principles. Among other things such a scheme would provide for the surplus profits to be apportioned between the employees in the concern and the ordinary shareholders; for opportunities to be given, where desired by the employees, for employee shareholdings and for all persons actively engaged in the business to be entitled to elected representation on the board of directors with consultative machinery at all levels.

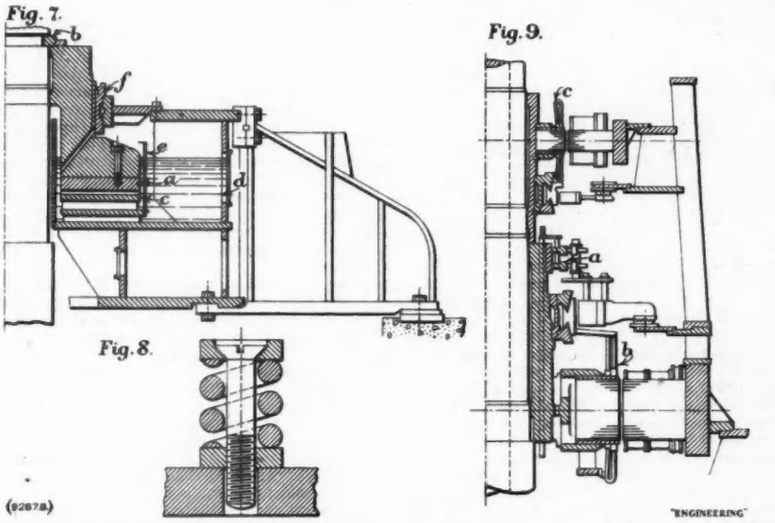
For nationalised industries, a policy of decentralisation would be adopted. Beginning with the coal industry, employees would share "efficiency profits" and have representation on the boards of management. The resolution also deals with inheritance, monopolies, house-ownership, and "fair play" for small shopkeepers.

On the recommendation of the executive of the National Union of Mineworkers, a delegate conference which met in London on Friday last, decided to continue the working of extra hours in the pits for another year. Each area was left to decide for itself how the extra hours should be worked—whether an extra half-hour should be worked on each of five days or a Saturday shift be introduced. The Scottish area executive, at a meeting in Edinburgh earlier in the week, had already decided to work an 11-day fortnight.

According to a survey of Canadian requirements for professionally-trained persons, conducted by the Bureau of Technical Personnel of the Department of Labour, an acute shortage of professional employees continued owing to the high qualifications required for the work. The country did not reach the maximum productive potential because of widespread man-power shortages, particularly of engineers. In recent months, the Bureau of Technical Personnel, which, together with the Executive and Professional Division of the National Employment Service, is concerned with the placement of engineers, has continuously had orders in hand for over 1,000 technically-trained personnel, while the number of applicants has steadily decreased.

VERTICAL-SHAFT TURBINE-DRIVEN ALTERNATORS.





THE DESIGN OF VERTICAL-SHAFT WATER-TURBINE DRIVEN ALTERNATORS.*

By E. M. JOHNSON, M.Sc., and C. P. HOLDER, B.A.

THE development of inland waterways and of large land irrigation and reclamation schemes in combination with the supply of electrical energy has greatly increased in recent years. The generating sets are usually of the low-head low-speed vertical-shaft type, and are often of large dimensions. The alternators differ considerably from horizontal-shaft generators of similar output, and their design involves many problems some of which also occur in the design of high-speed vertical-shaft generators. The principal factors that determine the speed of a water turbine are the available head and the output. For a given output, the speed falls with the head, and for a given head the speed decreases with increasing output. Large turbines for low heads therefore operate at very low speeds. In consequence, the alternators are large and many of the problems that arise in their design and manufacture are solely due to this fact. The overall height of such machines from the coupling face to the topmost point, including exciter, may be 25 ft. to 35 ft., with a further 10 ft. in the case of generators driven by Kaplan turbines. The approximate overall diameters of some recent examples of this type of machine are given in Table I.

A too-rapid change in the rate of flow of water into a turbine will cause surges and possibly dangerous variations in the penstock pressure. Any adjustment of the flow following a sudden change in load must therefore be relatively gradual; and the turbine speed may rise or fall considerably before it is finally restored to normal. The flywheel effect necessary to limit this so-called "momentary" speed variation is roughly proportional to the output in horse-power and inversely proportional to the square of the speed. In large low-speed units the total flywheel effect required is therefore considerable, and it is usually more economical to embody it in the generator rotor than in a separate flywheel. Moreover, if a sudden change from full load to no load were accompanied by a governor failure, the speed would rise to about twice, or in the case of Kaplan turbines, about thrice, normal. It is not practicable to check this by an emergency governor and the machines must therefore be capable of running safely at this overspeed.

TABLE I.—*Typical Large Vertical Water-Turbine Driven Generators.*

Output.	Speed.	Approx. Overall Diameter.	Country of Manufacture.
kVA.	R.p.m.	Ft.	
100,000	150	32	Germany.
90,000	83·3	41	United States.
75,000	128·6	38	Canada.
82,500	180	31	United States.
70,000	150	30	France.
52,500	428	16	Switzerland.
48,000	75	40	United States.
33,333	167	29	England.
14,000	46·9	37	Sweden.

Perhaps the most important advantage of the vertical-shaft design is that it permits the generator to be placed above and the turbine below the maximum tail-water level. Flooding of the generator is thereby avoided without sacrifice of head. As the weight of the rotating parts of the generator and turbine act in the same direction as the axial hydraulic thrust, a thrust bearing capable of carrying a relatively heavy load and of operating at the maximum runaway speed of the turbine is necessary. The usual modern practice is to make this bearing part of the generator, so that its design and that of its support is an important part of the generator design, as is indicated by the figures for loads and dimensions given in Table II.

The two factors that principally determine the cylindrical volume of a large vertical-shaft alternator are the power rating and the speed. Electrical characteristics, such as reactance, short-circuit ratio and permissible temperature rise, affect the dimensions to a very limited extent, because in a large diameter slow-speed machine the amount of electromagnetic material may be varied within wide limits with relatively little change in the diameter. The designer's problem is to proportion the cylindrical volume by choosing the diameter and axial length most suited to the particular case. Maximum efficiency is obtained by making the diameter as small as possible and the axial length correspondingly great. The axial length, however, is limited by the critical speed of the rotor and by the effect an increase in core length has on the ventilation of the machine. The ratio of core length to pole pitch on low-speed machines, however, may be as low as unity if more than a normal flywheel effect is necessary. In fact, in the majority of such generators, it is most economical to embody the flywheel effect in the rotor, even if this means an increase in the diameter.

TABLE II.—*Typical Thrust Bearings for Large Vertical Shaft Generators.*

Load.	Outside Diam.	Speed.	Normal Peripheral Speed.	Country of Manufacture.
Tons.	In.	R.p.m.	Ft. per Sec.	
1,340	112	75	36·7	United States.
1,130	96	120	50·2	" "
750	82·5	167	60·0	England.
140	48	428	90·0	Switzerland.

The rotors of water-turbine driven alternators are almost invariably of the salient-pole type. It is usually impracticable, however, to employ bolted-on poles owing to the large centrifugal forces which would occur at the runaway speed of the turbine. With laminated poles, some form of dovetailed or equivalent construction is generally necessary, but on high-speed generators of small and medium diameter, solid poles cast or forged integral with the rotor body can be used. The question of pole design is closely linked with the design of the rotor body, which, in turn, is governed by the flywheel effect required. Rotors can therefore be divided into two broad classes, those with laminated and those with solid poles. Laminated poles are used on all medium- and low-speed generators of the type under consideration. In machines with a peripheral speed not exceeding about 5,000 ft. per minute, the poles may be bolted to the wheel rim. This construction, however, is limited to machines of small flywheel effect or to those with a separate flywheel, since otherwise the depth of the rim would involve inconveniently long bolts. Typical constructions in common use are shown in Figs. 1 to 4. In Fig. 1, the pole is pressed into a recess in the rotor with a slight interference fit. This is the strongest form of dovetailed pole construction and is particularly valuable for high-speed machines with long cores. An alternative is shown in Fig. 2, the necessary tightness between the pole and wheel being in this case obtained by taper keys driven in from opposite ends. The construction most favoured to-day for all but the most highly stressed rotors is illustrated in Fig. 3. It is simpler to produce, erect and dismantle than those shown in Figs. 1 and 2, while an advantage, which it shares with the construction indicated in Fig. 2, is that the slot in the rotor need not have a smooth finish. A limitation in the construction shown in Fig. 3 becomes apparent by comparing it with Fig. 1. The centrifugal force of the poles is carried on the neck between the adjacent pole dovetails and the stress in the neck is greater with the T-shaped dovetail. However by the use of multiple T-heads, as shown in Fig. 4, the stress in the neck can be reduced and the range of application of the keyed-in pole, compared with the more costly and less convenient pressed-in pole, can thereby be extended. As many as three T-heads are sometimes used. An advantage possessed by the constructions shown in Figs. 3 and 4 is that the air gap can be adjusted by means of liners under the poles, thus allowing greater latitude in the electromagnetic design.

The rotor body may vary from a solid cylinder to a comparatively thin rim carried on a spider. In most of the machines in the category considered here the construction will be determined by the necessity of taking the machine to pieces for transport. The simplest type of body is the cast-steel magnet wheel which, except in the small sizes, is split diametrically, owing to difficulties of manufacture and transport, and joined after assembly by shrink rings. This construction is generally confined to rotors up to about 15 ft. in diameter. Within this limit longer machines may be constructed by placing two or more separate wheels side by side on the shaft. For higher speed machines, however, castings are incapable of supporting the stresses involved and a rotor body built up of rolled-steel discs is used. The individual discs may be 3 in. to 9 in. thick, and are machined all over and spigoted together; or they may be made from ½-in. boiler plate and held in correct alignment

* Paper read before the Institution of Electrical Engineers on Thursday, February 19, 1948. Abridged.

by fitted bolts. Where stresses permit, the shaft is usually pressed into the built-up rotor. For higher speeds, where a hole through the centre of the rotor body is not permissible, bolted-on stub shafts may be employed. This construction is appropriate to large high-speed machines up to 50,000 kVA at 428 r.p.m. In the rare cases in which this construction is not possible, owing to the high stresses, it is necessary to employ a non-salient pole design.

The disc rotor is not ideal for obtaining flywheel effect, since the centres of the discs contribute little to it and a great deal to the weight. The ideal construction would be a heavy rim on a light spider, but such a rim, if it were cut out of rolled-steel plate, or cast, would be uneconomical and its size would be subject to the same limitations as solid discs. These disadvantages are overcome by building the rotor of relatively thin steel plates, suitably shaped, overlapped and bolted together; and this is the general practice on water-turbine generators exceeding about 15 ft. in diameter. The segmental plates are usually $\frac{1}{8}$ in. to $\frac{1}{4}$ in. thick and are punched or guillotined to the desired shape. Each segment covers one or more pole pitches and successive layers are "staggered" so that each segment overlaps the one below. This construction is illustrated in Fig. 5, page 357, from which it will be seen that each segment covers three pole pitches. It will also be observed that the effective cross-sectional area of the rim carrying the hoop stress is two-thirds of the total. By making a segment cover more pole pitches and by suitably staggering the segments in one layer with those in adjacent layers, it is possible to increase the effective cross-sectional area to as much as five-sixths of the total. Beyond this the cost is prohibitive. Exceedingly accurate workmanship is necessary in the production of the rim segments to ensure that they register accurately on one another in consecutive layers in the rim. The difficulty of producing these increases with the number of pole pitches per segment owing to the number of ways in which the segments must register.

The bolts through the rim may either be fitted or have a slight clearance in the holes, the latter arrangement being preferable if the segments have to be taken apart for shipment. In this case it is the usual practice to clamp the rim so tightly that no slipping of the segments relative to one another can take place at any speed up to the maximum runaway speed of the turbine. Otherwise, the laminated rim may expand to the extent of the clearance in the bolt holes causing permanently distorted and reduction of the air gap. The thinner the laminations of which the rim is composed the greater the frictional force resisting slipping for a given tension in the bolts. Thin punchings are, therefore, often preferred to plates in the construction of built-up rims. By a suitable choice of the segment thickness and a proper disposition and proportioning of the bolts, rims can be made non-slipping at the highest working stresses. The keyed-in pole is admirably suited to a laminated rim, one of its advantages being that it is not dependent upon smooth machined surfaces, as is the pressed-in pole, so that the slightly irregular surfaces of the built-up rim present no difficulty.

The laminated rim merely rests on the spider arms and is driven by floating keys. The arms are thus relieved of all centrifugal stresses, except those due to their own weight. The spider arms may either be cast integral with a central hub, pressed on and keyed to the shaft, or they may be fabricated from steel plate and bolted to a separate cast hub or to flanges on the shaft. A typical method of attaching the spider arms to a separate hub is shown in Fig. 6, page 357. The arms are secured by bolts (preferably tapered) to two steel rings which are themselves attached in the same way to flanges on the central cast-steel hub. The taper on the bolts ensures that the stresses due to the torque shall be reasonably equal in all bolts. It also enables the bolts to be removed easily. A principal object of the construction illustrated is to allow the rotor to be detached from the hub. This is done by removing the two inner circles of bolts so that the rotor can be lifted without its shaft, the arms being united by two rings. It has the further advantage in certain applications of allowing all the bearings to be placed in position before the rotor is erected.

Some vertical-shaft alternators have a thrust bearing and two guide bearings, the latter being placed one above and one below the rotor. The turbine usually has one guide bearing, making a total of three for the unit. There is, however, an increasing preference for one guide bearing only in each machine. The principal factor in the bearing arrangement is usually the position of the thrust bearing; and in an increasing proportion of the larger generators this is placed below the rotor. This is particularly the case with large diameter low-speed machines. These include a variant in which the upper guide bearing is omitted giving what is known as the "umbrella" type of construction. The principal consequences of placing the thrust bearing above the rotor are that it is generally easier of access; the shaft diameter being smaller above the rotor than below it, the diameter of the thrust bearing, and hence the losses in it, will be a minimum; the stator frame has to carry the load transmitted to it by the thrust bearing arms. The disadvantages of placing the thrust bearing below the rotor are that it is larger and less accessible. On the other hand, the vertical load on the bearing is transmitted directly to the concrete of the foundations and the turbine casing without having to be carried by the stator frame. The arms supporting the thrust bearing have only to span the turbine pit, so that their depth and weight are reduced. If the rotor is easily removable from its shaft, it can be lifted out of the stator without uncoupling the turbine shaft. Owing to the arms supporting the thrust bearing being shallower, the overall height of the generator is less. These advantages also apply to the umbrella type of construction. In addition, the first cost and bearing friction of the latter are less, the lubricating arrangements are simpler, and the rotor is more accessible. When the exciters are separately driven, there is also no need for a heavy upper bracket, except with a Kaplan turbine. Further, the station head-room and crane height are somewhat less than for a machine with two guide bearings.

The thrust bearing consists essentially of a collar or runner, which is rigidly mounted on a specially-formed stationary member. Such bearings, of which a typical example is illustrated in Fig. 7, on page 357, run submerged in oil, which is circulated by the centrifugal pumping action of the collar. Correct alignment of the runner face *a* in relation to the shaft is of great importance, otherwise eccentric running of the rotor, journals and couplings will result. Accurate machining of the large parts involved is therefore necessary and the runner must be rigidly seated on the shaft. This is assured by making the seat sufficiently long and providing an adequate interference fit. The axial thrust is transmitted from the shaft to the runner through a ring key *b*, which embraces the shaft and fits accurately into a slot in its circumference. This key is divided into two or more segments which are prevented from working out radially by locking plates on the runner. The bearing surface of the runner *a* is of mild steel or of special close-grained cast iron, ground and lapped to optical accuracy. The stationary part is divided radially and consists of white-metal faced pads *c*, mounted so that they are free to tilt slightly in operation and thus to form a wedge-shaped film of oil between the rubbing surfaces. Except when the machine is stationary, there is no contact between the metal surfaces, for as soon as the runner begins to move an oil film forms. Wear in the bearing can occur therefore only during the first fraction of a revolution at starting, and the last fraction of a revolution at stopping. The coefficient of friction is between 0·001 and 0·005 when running, whereas at standstill it may be 0·2, or more.

Correct alignment of the bearing surfaces is essential to ensure that the load is equally divided between the several pads. Most of the variety in thrust-bearing design arises from the different methods of tilting the pads and aligning the stationary and rotating members. In the Michell and Kingsbury bearings, the pads are tilted by supporting them upon separate pivots about which they may rock in one or more directions, the correct distribution of the load being ensured by screw adjustments of the pivot height. In another pattern of bearing, the pad is integral with a small neck or column so that it is able to tilt under the pressure of the oil wedge. With thrust bearings of these types the deflection of the supporting bracket must be small; otherwise the alignment of the pads will suffer. An alternative free from this limitation is the spring-supported thrust bearing in which tilting and equal distribution of the load are accomplished by mounting each pad on a number of short helical springs standing on a rigid baseplate. In order to prevent too much flexibility in the springs, they are pre-compressed by a screw and washer, as shown in Fig. 8, page 357. The amount of pre-compression is approximately equal to the load that the spring will have to carry in service, and the overall height of each spring is adjusted to ensure that it will carry its fair share of that load. The segmental pads, of which there may be six to twelve, according to the size of the bearing, rest on the top of the springs and are prevented from turning with the runner by keys attached to the baseplate. A large bearing of this type may contain over 1,000 springs.

An important consequence of the complete immersion of the bearing in oil, as shown in Fig. 7, is that the rotation of the runner *a* imparts a rotary movement to the oil, which, unless prevented, will form a vortex. There would, therefore, be a risk of the pads being deprived of oil. To eliminate this, an adequate head in the oil port *d* is essential, but if this means alone were adopted, the overall height of the machine would be undesirably increased. It is therefore usual to fit a stationary baffle round the runner, as shown at *e*. The proportions of this baffle are critical and must be well chosen; otherwise, the oil may be thrown clear of the bearing. In a thrust bearing of this type the peripheral speed of the runner *a* at overspeed may reach 145 ft. per second (100 m.p.h.), but tests on full-scale models have proved that such a baffle will function successfully at speeds in excess of this.

The guide bearings of large vertical-shaft generators are commonly either of the plain sleeve or pivoted-pad types. They may be 5 ft. or more in diameter, but the loads are usually low and the axial length is short compared with the diameter. The length of a bearing of this size would be about 12 in. The radial clearance in the guide bearings of vertical-shaft generators should be kept as small as possible compatible with freedom from trouble in service due to differential expansion of the journal and housing. The clearances are commonly no more than one-third of those used in horizontal sleeve bearings. The vertical arrangement of the bearing introduces problems not met with in horizontal machines. As shown at *f* in Fig. 7, when a guide bearing is placed immediately above the thrust bearing, oil can be supplied to it by centrifugal action through passages in the runner *a*. Guide bearings that are separate from the thrust bearings are sometimes lubricated in a similar way by making the journal on a collar on the shaft and partially submerging it in oil.

In most vertical-shaft generators artificial cooling is necessary, at least for the thrust bearing, and water is the usual cooling medium. The simplest method of water cooling the oil is in a cooler placed in the bearing reservoir, this cooler consisting either of a single nest or a number of separate banks of tubes. The latter type is generally preferred on large machines and has the advantage that the units can be removed one at a time for cleaning or repair through openings in the side of the thrust-bearing housing; the same openings then serve for the removal of the thrust pads. External coolers are, however, better for large generators provided adequate steps are taken to safeguard the circulation. In a recent development, motor-driven pumps are dispensed with and the oil is circulated by the centrifugal pumping action of the thrust-bearing runner itself.

Large alternators in hydro-electric power stations are to-day usually provided with closed-circuit ventilation, the fans being integral with the machine. The best arrangement is to divide the cooling plant into from four to twelve units, which are mounted on flats on the outer periphery of the stator frame. The generator ventilating air is often used for heating the station during the cold season. This reduces one of the great advantages of closed-circuit ventilation, which is the protection it gives against major fire damage by restricting the supply of oxygen and permitting the injection of carbon dioxide. The full advantages of the system can, however, be retained by the use of heat exchangers whereby the heat in the ventilating air is given up to an entirely separate stream of air, which is used for station heating.

The rotor of a water-driven alternator, revolving freely, may take half an hour or more to come to rest owing to its high moment of inertia. This may have serious consequences in the event of fire or mechanical failure, and is also a great operating inconvenience. Vertical-shaft generators are, therefore, almost invariably provided with mechanical brakes. These brakes have the further advantage of reducing the wear in the thrust bearing as the oil film tends to fail when the speed falls below 1 r.p.m. and metal-to-metal contact can occur. The more rapidly, therefore, the rotor is brought to rest from this point the better. The number of brakes varies according to requirements, and as many as 32 have been used. They are located on the bracket below the rotor and bear against a circular track on its underside. Each brake has its own cylinder and may be operated by air or oil at about 100 lb. per square inch pressure. When oil is used, it is preferably forced into the brake cylinders from a closed vessel by the admission of compressed air, thus providing a cushioning effect which prevents too violent an application. The brakes are not usually applied until the rotor speed has fallen to about half normal in order to reduce the wear on the linings. This involves no great loss of time as the windage and friction torque, down to half speed, is usually sufficient to maintain an adequate rate of retardation. The brakes provide a convenient means of lifting the rotor for flooding the thrust-bearing face at starting and for the inspection of the pads. A pressure of about 1,000 lb. per square inch is required for this purpose and is obtained from a small hand- or motor-operated oil pump, which is often made portable so that it can serve a number of generators. The vertical lift in jacking is usually about $\frac{1}{2}$ in.

The stators of large vertical-shaft water-driven alternators follow conventional lines, except for their horizontal position and the provision that has to be made in the frame for carrying the load transmitted by the upper bracket. The frame is usually made in four parts for ease of transport, with bolted and dowelled joints between adjacent parts. The particulars given in Tables I an II indicate that the thrust-

bearing bracket may have to support a load approaching 1,500 tons and may have to span 30 ft. to 40 ft. In generators driven by Kaplan turbines, the hydraulic thrust may account for 30 per cent. to 50 per cent. of the load on the thrust bearing. The load on the bracket increases considerably when the water thrust is applied. Clearances in the turbine are small and, in consequence, the deflection permitted in the thrust-bearing bracket is also small, a total of ¼ in. being considered reasonable for large brackets. Greater rigidity, however, is sometimes required for the less flexible types of thrust bearing. It is always necessary to ensure that critical vibration frequencies cannot occur in the structure.

In the majority of cases either the thrust-bearing bracket is self-contained and carries the thrust bearing upon it, or the thrust-bearing housing is an integral part of the bracket. In the first arrangement, the centre of the bracket is not interrupted by the large hollow of the thrust-bearing reservoir; consequently, the requisite rigidity is obtained with a lighter and shallower bracket than in the second. On the other hand, since the thrust bearing is placed on top of the bracket, the overall height of the machine may be greater with the first arrangement than with the second. The two principal forms of bracket are a simple bridge comprising two parallel girders, or six or eight radial arms supporting a central hub. The former construction is usually confined to machines not exceeding about 25 ft. in diameter and having thrust-bearing loads of not more than about 300 tons. It is also used mainly for thrust bearings mounted above the rotor. The radial arm bracket is used on all the larger machines. The arms are bolted to the central member, keys or spigots being employed to take the heavy shear load at the joint, as shown in Fig. 7. With the bearing above the rotor, a multi-arm bracket gives a more uniform distribution of the thrust load on the stator frame and foundations, while when it is below the rotor the span of the bracket is reduced; a saving in cost and height therefore results. In this position also the bracket forms a convenient support for the brakes and jacks. In umbrella-type generators not driven by Kaplan turbines a bracket carried on the stator frame must be provided to support the exciters if these are directly coupled. This bracket, although carrying only a relatively light load, is of considerable size and its elimination is one of the advantages claimed for separately-driven exciters. In generators driven by Kaplan turbines a bracket is necessary to support the blade-operating mechanism and the same bracket will also carry the exciters.

The stator and field windings of large vertical-shaft water-turbine driven alternators do not differ in any essential respect from those of other types of alternating-current generators. On account of the high overspeed, special attention must be paid to the clamping of the field-coil connections and the coil ends, while damper windings are fitted to increase stability under system disturbances and to reduce the risk of overvoltage in certain conditions of unbalanced short circuit on long open-ended high-voltage transmission lines. These windings, apart from their cost and complication, have the disadvantages of increasing the losses on load and giving rise to higher fault currents owing to the lowering of the sub-transient, negative-sequence and zero-sequence reactances. On account of the increase in length and capacitance of transmission systems, the advantages of these windings are, however, now generally considered to outweigh their disadvantages.

Large vertical-shaft water-turbine driven alternators are usually connected to transmission lines and have therefore to be capable of working at low leading power factors for line charging. This usually necessitates an overall range of excitation greater than can be obtained from a shunt exciter. Most large generators of this type are therefore provided with a pilot or sub-exciter to energise the field of the main exciter. A rapid rate of exciter response, to ensure adequate stability under fault conditions, is also necessary. The main exciter is therefore designed to have a maximum voltage equal to twice the normal excitation voltage and a rate of exciter response equal to the maximum voltage change per second. Exciters are usually directly-coupled and their armatures are then overhung from the main shaft. At the low speeds of rotation for which so many machines of this type are built, directly-coupled exciters tend to be very large and to have high time-constants and costs. For this reason separate high-speed exciters are sometimes employed. Directly-coupled exciters are usually arranged with their commutators upwards. In a recent design, however, the armature of the pilot exciter is inverted so that the two commutators are nearly adjacent. In this arrangement, as shown in Fig. 9, on page 357, the generator slip rings *a* are placed between the commutators of the main exciter *b* and the pilot exciter *c*, so that the three sets of brush gear, the commutators and slip rings are all in one large compartment within easy reach of an attendant standing on a platform at the base of the main exciter. An alternative construction, aimed more at reducing height than increasing accessibility, employs a pilot exciter partly within the main exciter.

The use of an electric drive for governor pendulums, instead of belts and gears, has become almost universal in recent years for large vertical-shaft units. The governor is driven by a self-starting synchronous motor supplied from a 1 to 5 kVA three-phase generator, which is mounted on the main-generator shaft system. For simplicity and security, the revolving field of the generator governor has permanent-magnet poles of an aluminium-nickel-cobalt alloy. Thus slip-rings, brushes and excitation connections are avoided. The governor generator, being a machine of small air gap, is usually mounted near a main guide bearing. In machines of comparatively high speed the air gap of the governor generator will be larger and may safely be mounted at the summit of the set, especially if the main generator has a guide bearing above the rotor.

The problem of voltage control is made more difficult by the momentary rise in speed which occurs when large blocks of load are switched off. This rise influences both the generator and the exciters and may lead to a dangerous rise of voltage. To cope with this through the exciter fields introduces an undesirable time-lag and it would therefore be desirable to regulate the field current of the generator directly. This, however, is almost impossible with conventional means owing to the large amount of energy stored in the magnetic field. A solution recently adopted is based on the assumption that the sudden loss of a large block of load is an isolated event. It consists of switching into the generator field a resistance sufficient to limit the voltage rise to, say, 10 per cent., with the generator on open circuit at, say, 30 per cent. above normal speed. The automatic voltage regulator then introduces its resistance into the exciter field system, and after sufficient time has elapsed for the exciter voltage to have fallen to a value corresponding roughly to an open-circuit generator voltage 10 per cent. above normal (say, 2 seconds), the resistance in the main field circuit is short circuited. The emergency voltage-control system then becomes inoperative until re-set.

The synchronous reactance of large water-turbine driven alternators is usually about 1 to 1·3 (per unit). Considerations of system stability rarely permit a value of 1·3 to be exceeded, but values as low as 0·5 are sometimes necessary when generators have to work in parallel at opposite ends of a long transmission line. When these alternators are connected to such lines provision for line charging is necessary and they have to be capable of stable operation at normal or lower voltage and zero leading power factor. In order to provide adequate voltage control at the full leading-current output an adequate margin of positive excitation is necessary and the short-circuit ratio must not be less than a certain value. Moreover, the exciter must not be unstable at the low values of excitation required for line charging. This is one of the reasons why alternators of the kind under construction have pilot exciters.

IRON AND STEEL INSTITUTE AWARDS.—The Council of the Iron and Steel Institute have awarded the Bessemer Gold Medal for 1948 to Mr. W. J. Dawson, C.B.E., formerly of Messrs. Hadfield's Limited, in recognition of his contributions to the development of steel castings and to the production of alloy and heat-resisting steels. The Sir Robert Hadfield Medal for 1948 has been awarded to Mr. A. Preece, of the University of Leeds, in recognition of his researches on the scaling, over-heating and burning of steel. The Williams Prize for 1947 has been won by Mr. R. Fowler, of Messrs. Richard Thomas and Baldwin's Limited, author of the paper, "Blowing Out a Blast Furnace," printed in April, 1947. The presentations will be made in the morning of Wednesday, May 5, during the annual general meeting of the Institute, in the lecture hall of the Royal Institution of Chartered Surveyors, 12, Great George-street, London, S.W.1.

FOUNDERS COMPANY FELLOWSHIPS.—The Worshipful Company of Founders of the City of London award Fellowships giving facilities for advanced education to men who have already completed their normal course of training at a university or other suitable educational establishment. Fellows are chosen by a selection committee from among applicants who have completed their training in chemistry, physics, metallurgy and allied sciences. In addition, some previous foundry training and experience, together with, if possible, the diploma of the British Foundry School, would carry weight with the committee. Moreover, attention will be paid to the character and powers of initiative of the candidate. The normal value of the Fellowship is 300*l.* per annum, and it will be renewable for a second year, and, in special cases, for a third year. One Fellowship is granted each year, and candidates should be not less than 21 years of age on September 1 of the year of application. Applications must be received not later than May 1 by the Clerk, Worshipful Company of Founders, Founders' Hall, 13, St. Swithin's-lane, London, E.C.4, to whom all inquiries should be addressed.

CATALOGUES.

Rubber-Metal Bushes.—Data on the rubber-metal bushes manufactured by Messrs. Metalastik, Limited, Evington Valley-road, Leicester, are given in a catalogue received from the firm.

Spray-Painting Guns.—Messrs. B.E.N. Patents, Limited, High Wycombe, Buckinghamshire, have sent us a copy of a new illustrated leaflet (reference No. C.B. 61a) containing details of their range of equipment for use in spray painting.

Dividing head.—Particulars of the O.M.T. universal dividing head are given in a leaflet issued by the makers, Messrs. Optical Measuring Tools, Limited, 414, Montrose-avenue, Trading Estate, Slough, Bucks. It is of trunnion design and can be used for plain or differential indexing on all standard milling machines.

Concrete in Gasworks.—The Cement and Concrete Association, 52, Grosvenor-gardens, London, S.W.1, have published a 30-page brochure containing well-illustrated descriptions of concrete coal-storage bunkers, retort houses, coke conveyors, cooling towers and other plant recently erected at gasworks in this country.

Mine Telephones and Signalling Equipment.—A catalogue issued by Automatic Telephone and Electric Company, Limited, Strowger Works, Liverpool, deals with the mineshaft and haulage signalling equipments and systems, which have been specially designed by the firm for use in coal mines. Mining telephones are also described.

Automatic Screw Machine.—The No. 48 single-spindle automatic screw machine made by Messrs. B.S.A. Tools, Limited, Birmingham, is described in a leaflet issued by the sole agents in Great Britain, Messrs. Burton, Griffiths and Company, Limited, Marston Green, Birmingham. The machine will produce components up to ¾ in. in diameter at high speeds.

Industrial Matting.—Messrs. Nuway Manufacturing Company, Limited, Endurance Works, Coalport, Shropshire, have sent us a folder describing their Nuway industrial matting, consisting of tough reinforced fibre and rubber links woven on galvanised high-tensile steel wire of U-shape. The matting is stated to be particularly suitable for use in factories and engineering works.

Infra-Red Heating.—A pamphlet dealing with the application of electric lamp infra-red heating to industrial processes has been issued by Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. It contains well-illustrated descriptions of the apparatus available for this purpose, as well as a great deal of useful information on both the theoretical and technical aspects of the subject.

Jig Borers.—Nos. 1 and 2 jig-boring machines made by the Newall Engineering Company, Limited, Peterborough, are described in two leaflets issued by the firm. Both machines are designed to provide as much space as possible for the workpiece, and both are fitted with the Newall patented system of linear measurement, which employs a series of lapped rollers, and ensures that the setting of the table is accurate to within a tolerance of 0·0002 in.

Horizontal Boring Machines.—Messrs. Soag Machine Tools, Limited, Juxon-street, Lambeth, London, S.E.11, are British Empire agents for the Gilly high-speed universal horizontal boring machines, which are made by S.A. des Forges, Usines et Fonderies de Gilly, near Charleroi, Belgium. A leaflet describing and illustrating the machines includes particulars of table-type machines with fixed columns and travelling tables, and floor-type machines with travelling columns.

Pneumatic Tube System for Tickets.—A pamphlet describing the pneumatic ticket tubes which have been adopted as standard by the British Post Office, has been issued by Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2. The principal application of these tubes is in trunk and toll telephone exchanges, where it is used for routing the large number of stiff paper tickets on which particulars of the originating telephone calls are noted. The tubing is rectangular in section and the ticket, one end of which is turned up to form a "sail," is carried through it by air at a speed of 20 ft. to 30 ft. per second.

Clip-on Ammeter.—An extension of the firm's well-known range of dual-range clip-on ammeters is described in a pamphlet published by Messrs. Ferranti, Limited, Hollinwood, Lancashire. This consists of a split-core transformer and rectifier instrument with a 2½-in. dial, which is housed in a Bakelite case and is designed for use on bare conductors operating at voltages up to 600. Seven current ranges, with maxima of 10, 25, 50, 100, 250, 500 and 1,000 amperes, are provided, and these can be selected by a thumb-operated switch. Still smaller currents can be measured by looping the conductor twice or more through the core aperture and dividing the reading by the number of turns. All the metal parts, except the magnetic contact surfaces, are protected by insulating material. The net weight is only 3 lb.

NOTES ON NEW BOOKS.

Daimler, 1896 to 1946. By ST. JOHN C. NIXON. G. T. Foulis and Company, Limited, 7, Milford-lane, Strand, London, W.C.2. [Price 42*s.*]

THIS "record of 50 years of the Daimler Company," to quote its sub-title, is an admirable example of industrial history as it should be written much more frequently, and is assured of a permanent place in the definitive literature of automobile engineering. It traces the story of the Daimler car from the first meeting of F. R. Simms with Gottlieb Daimler in Berlin, some 60 years ago, through all the vicissitudes and tribulations that beset the pioneers of motoring in this country, to the great organisation of the Daimler Company as it exists to-day. The early stages are notably well documented, and there is a profusion of excellently reproduced illustrations, including some interesting facsimiles of correspondence and company prospectuses. A full report is given of the remarkable test, in 1909, of two Knight sleeve-valve engines, made to disprove the doubts which were then general regarding the reliability of this type. The engines were given a full-power non-stop bench test of 132 hours under R.A.C. observation; fitted to two chassis and driven to Brooklands for a further test of 2,000 miles, and back to Coventry; and then given a further bench test of five hours before being opened up for inspection, when they were found to show "no perceptible wear." The book concludes with an account of the company's war work, a glossary of notable events in their history, and tabulated particulars of all models made from 1897 to 1946.

The Story of the West Highland. Second and enlarged edition. By GEORGE DOW. Eastern and North-Eastern Regions, British Railways, 11, Blandford-square, London, N.W.1. [Price 3*s.* 6*d.*]

IN the second edition of this booklet, Mr. Dow has added a chapter on the West Highland Railway in war-time (more accurately—the West Highland section of the former L.N.E.R.). New marshalling yards at Ardmore, between Cardross and Craigendoran, and additional sidings at Craigendoran, were constructed to meet the requirements of military traffic. Faslane, once a quiet bay on the Gareloch, became Military Port No. 1 during the war, with six berths, each 500 ft. in length and with 30 ft. of water at low tide. A line was constructed from Faslane Junction to the port, and it was worked by the Army for training purposes. At many other places on the West Highland, the war brought a considerable increase in traffic, and in some cases extensions of traffic facilities. The first edition of the booklet was published in 1944, to commemorate the jubilee of the opening of the first section of the railway, between Craigendoran and Fort William, in August, 1894, and by bringing it up to date in the second edition the author has preserved its excellent balance. He deals with the history of the line, the principal engineering features, the locomotives, and the train services. The booklet is well illustrated, as becomes a history of the "iron road to the Isles." It is unfortunate that the scale on the map of the railway is about 25 per cent. in error, making Scotland appear to be a smaller country than it is.

Gradients of the British Main-Line Railways. The Railway Publishing Company, Limited, 33, Tothill-street, Westminster, London, S.W.1. [Price 10*s.*]

THE gradients and mileages of British main lines and the principal subsidiary and branch lines were first published in *The Railway Magazine* in 1929 and 1930. Later, a book containing this information was published, and several editions were printed before the war. The book under review, however, may be regarded as new. The line diagrams have been entirely redrawn, and several additional routes have been included, notably those between Shrewsbury and Newport; Inverness, Wick and Thurso; Dingwall and Kyle of Lochalsh; Callander and Oban; and some alternative routes on the Southern Region. In addition to gradients, the diagrams show all stations, halts, junctions, mileages, speed restrictions, etc. Although, of course, the vertical scale of the diagrams is greater than the horizontal scale, the two scales are constant throughout the book. It is therefore easy to observe the relative severity of different lines. Railway students will find the book a valuable aid to the observation of locomotive performance.

SOCIETY OF ENGINEERS.—The examinations of the Society of Engineers will be held on May 4 and 5, and applications to be examined will be accepted up till April 20. The rules, syllabus, and the list of exempting qualifications may be obtained on application to the secretary, 17, Victoria-street, London, S.W.1.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

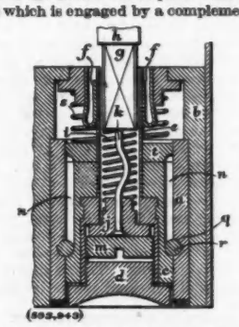
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

593,943. Brush Holder for Electric Machines. Rotax, Limited, of London, and W. F. Gilbert, of London. (2 *Figs.*) June 20, 1945.—This invention relates to brush holders used in dynamo-electric machines for carrying the brushes which press on the commutator or slip rings. The object of the invention is to enable the brushes to be easily mounted in position or removed for inspection or renewal. A socket *a* having a cylindrical bore is attached to the body *b* of the dynamo-electric machine. Sliding in the socket *a* is a cylindrical plunger *c* made from insulating material. At its outer end the plunger *c* is provided with a removable end piece *d* through which finger pressure can be applied to the plunger, this end piece being also made from insulating material. Arranged coaxially with and partly within the plunger *c* is a hollow metal piece *e* which extends beyond the inner end of the plunger and co-operates with a resilient contact or contacts *f* at the inner end of the socket, the remainder of the piece *e* being embedded in the plunger. The rear end of the hollow metal piece *e* has an internal screw thread which is engaged by a complementary screw



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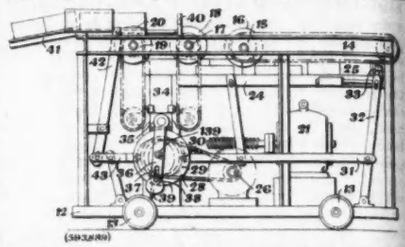
thread on the removable end piece *d*. The brush *g* is carried by the hollow metal piece *e* and is pressed into contact with the commutator or slip ring *h* by a helical spring *i*. At the end remote from the brush *g* the spring *i* is supported by a metal abutment *j* to which the brush is connected by a flexible conductor *k*. The abutment is clamped between a shoulder in the hollow metal piece *e* and a securing piece *m* in screw-thread engagement with the metal piece. In the outer peripheral surface of the plunger *c* is formed a pair of specially shaped loop-like grooves *n* which are open at the inner end of the plunger. A pair of balls *r* are carried in two diametrically opposite recesses *q* in the socket *a* and these balls engage the loop-like grooves in the plunger *c*. At the inner end of the socket *a* is a helical compression spring *s* which tends to move the plunger *c* in the outward direction, and between the adjacent ends of this spring and the plunger is placed a separate piece *t* which, when the plunger is extracted, serves to hold the balls *r* in position. The shape of the grooves is such that on inserting the plunger *c* in the socket *a* by the pressure of a finger the plunger is located in its operating position by the action of the balls *r* in the grooves *n* and held there by the pressure of the spring *s*. (*Sealed.*)

MISCELLANEOUS.

593,889. Manufacture of Bricks. Eastwoods Flettons, Limited, of London, and J. Paisley, of Kempston-Hardwicke, Bedfordshire. (3 *Figs.*) June 19, 1945.—This invention is a machine for scoring the surfaces of bricks before firing to assist in giving a key to the mortar, cement, concrete or other jointing material. It can also be adapted to coat the bricks with sand or other material to improve their appearance. A main frame 12 is mounted to run on wheels 13 and has upper horizontal frame members 14 in which are journalled three rollers having upstanding V-shaped projections arranged helically. The first roller 15 having end flanges 16 effects scoring on horizontally moving surfaces; the second roller 17 having end flanges 18 and the third roller 19 having end flanges 20 both effect scoring on vertically moving surfaces. An electric motor 21 on the main frame coupled to a reducing gear actuates both the rollers and the chargers for moving the bricks. A horizontal platform 24 receives the bricks 25. The worm-wheel shaft 26 drives a shaft carrying discs 28; one cam groove indicated in dotted lines at 29 engages pins 30 on horizontal links 31 having pin and slot connection with upright links 32 which impart to the horizontal charger 33 an intermittent stroke equal to the length of a brick. The bricks 25 during their forward horizontal movement are scored by roller 15. At the end of platform 24 is a gap to accommodate the vertical plunger 34 which engages under the bricks and is pushed up by crosshead 35 having connecting rods 36 carrying rollers 139 and



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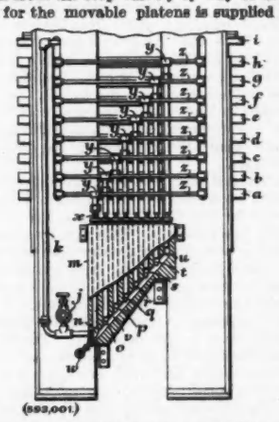
slotted at 37 to engage crankpins 38 which also carry the cams 39 for engaging rollers 139. When a pair of bricks 25 are in position above plunger 34 they are pushed up between rollers 17 and 19 and are scored on their ends (headers) and on reaching the charger 40 they are pushed on to the discharge chute 41. The charger 40 is actuated through the links 42, 43 from a cam. The vertical movements of the plunger 34 are arranged to have a definite dwell at both top and bottom positions to allow for the feed and the delivery of the bricks thereon. The crosshead 35 rests on stops during the bottom dwell while crankpins 38 move in the slots 37, and at the top of the stroke the cams 39 and rollers 139 determine the position of the plunger, the rollers 139 then being in contact with the radially outwardly directed dwell surface of the cams 39 after operation thereby while the crankpins 38 again move in slots 37. (*Sealed.*)

593,001. Steam-Heating Presses. Foster, Yates and Thom, Limited, of Blackburn, Lancashire, and D. Pole-Welman, of Blackburn, Lancashire. (4 *Figs.*) June 6, 1945.—This invention relates to the heating of the platens of presses for veneering and for making plywood and laminated plastics. Such presses are usually supplied with steam or heating fluid by flexible or telescopic pipes or by deflectional pipes in which pipe lengths are coupled by knuckle joints. The object of the invention is to provide an improved construction for supplying heating fluid to the platens. The illustration shows a veneering press consisting of eight movable platens *a* to *h* and one fixed platen *i*. Steam is supplied to the fixed platen from the stop valve *j* by way of the pipe *k* and steam for the movable platens is supplied by way



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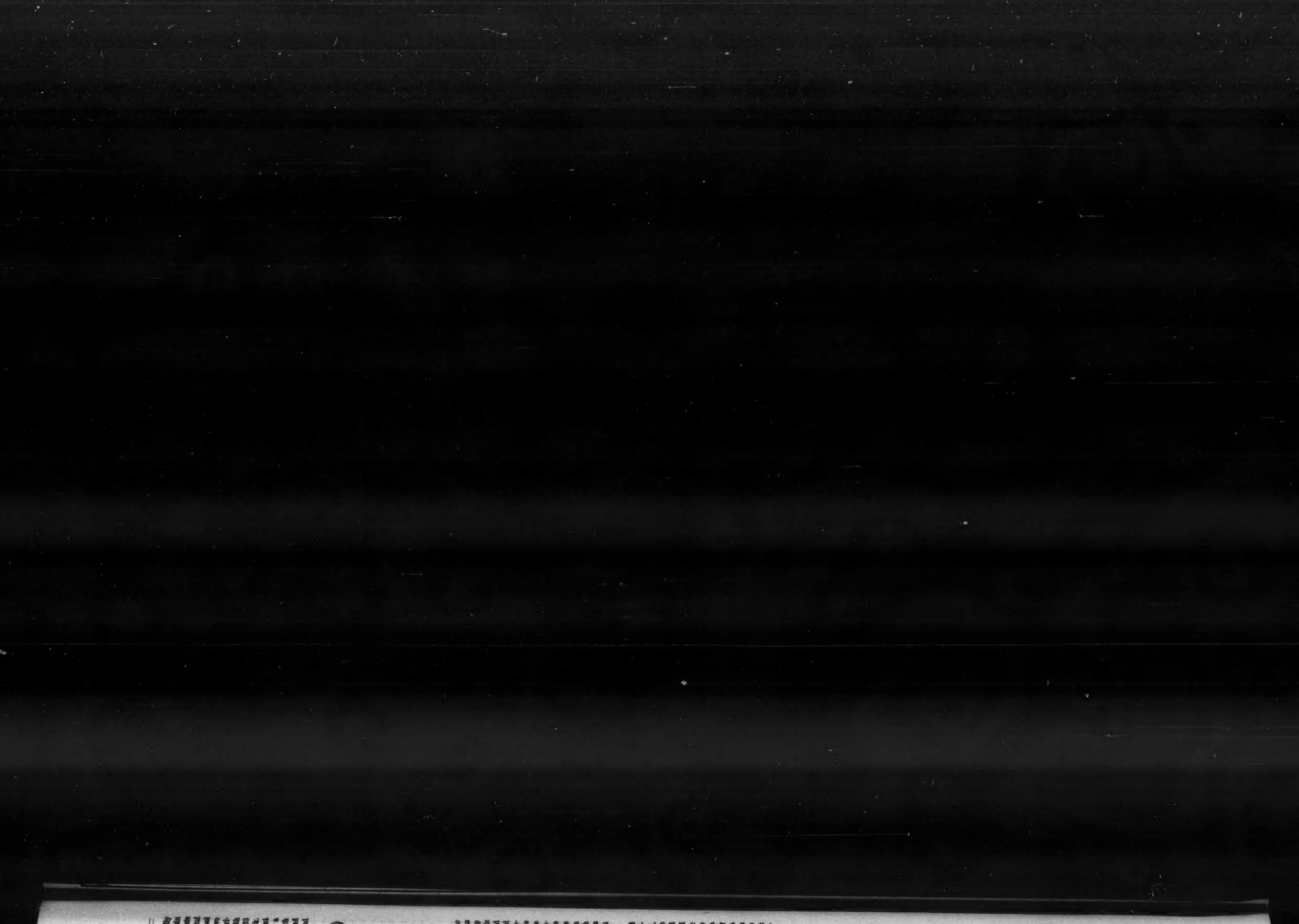
of the stop valve *j* to the header *m*, which comprises eight compartments *n-u* interconnected at their bases by the passage *v*, which also acts as a drain for condensate. A drain cock is provided at *w* at the bottom of the header. Into each compartment of the header extends a pipe *x*, which passes through a stuffing box in the top of the header and has a T-piece *y* at its top by which it is connected to a pipe *z* which extends along a platen and is coupled to it at its ends. At the opposite side of the platens there is a similar arrangement for the exhaust steam leaving the platens. As the movable platens are raised and lowered, the pipes *x* slide through the stuffing boxes in the header *m*. The movement of the lowest platen *a* is the greatest and therefore the header *m* is deepest where the pipe *x* from the platen *a* is located in order to accommodate this movement. (*Sealed.*)